A TIME-SERIES SIMULATION APPROACH TO THE CONSEQUENCES OF EXPORT INSTABILITY FOR DEVELOPING COUNTRIES - THE CASE OF POST-WAR GHANA

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Submitted to the Economics Department of the University of Warwick for the degree of Doctor of Philosophy

April 1981

TABLE OF CONTENTS

Page

APPENDICES

TABLES

Page

ACKNOWLEDGEMENTS

I would like to thank my supervisors at Warwick: Professor A.G. Ford and N.J. Ireland, for their guidance in the presentation of this thesis; and staff seminars at the Universities of Sussex and Bradford for their constructive comments. Any remaining errors are, of course, my own.

Thanks are also due to Roy and Karen of the Mannville Arms, Bradford, for their spiritual support over the last two years.

SUMMARY

The object of this thesis is to examine the effects of export instability on post-war Ghana by seeking to identify the mechanism through which fluctuations were transmitted from the export to the domestic sector. This involves the construction and estimation of a macroeconomic model over the period 1956 to 1969, and the analysis of its dynamic properties by means of simulation. It is intended to extend our knowledge in this area of development economics by switching the focus of analysis to a time-series basis and demonstrating how the consequences of fluctuations in exports depend critically on the structural characteristics of an economy and the assumptions made about behaviour under uncertainty. We believe that this provides both the basis of an alternative methodology to the one currently in use, and a detailed investigation of one particular economy.

In chapter 1 we present some background to the debate and outline the methodological framework employed. It includes a critical review of the literature, some historical background on Ghana, the reasons for its selection as a case-study; and an explanation of the methodology adopted in this study.In chapter 2 the general nature of the cocoa market is discussed, a model of the cocoa market is constructed and estimated, and its linkages with the Ghanaian economy explained. In chapter 3, a macroeconomic model for Ghana is estimated and discussed in the light of hypotheses about the transmission of export fluctuations. In chapter 4, this model is simulated to investigate its dynamic properties and to quantify the implications of export market fluctuations.

In our conclusion, we suggest that our methodology provides a useful basis for further research; and that export instability had important, albeit complex, repercussions on the Ghanaian economy over the time period under investigation.

CHAPTER 1 : INTRODUCTION

1.1 Export Instability - A Review

The problem of export instability in the context of 'lesser-developed countries' (LDCS) has for a long time been a topic of serious concern for development economists and a focus of attention for policy-makers. Its importance is highlighted by continuous 'north-south' dialogue over internationally coordinated measures to stabilize primary commodities or provide some means of financial compensation[1].

Although a considerable amount of work has now been done in this area, there remains a somewhat tenuous linkage between the various strands of the literature. This section therefore provides a brief review of research into the consequences of unstable exports for LDCS. In (1) we present the early debate; in (2) a summary of more recent work; and in (3) a critical evaluation of the literature[2].

(1) The early debate

Until MacBean's controversial work (MacBean 1966) the predominant view amongst development economists was that LDCS (usually assumed synonomous with primary producers) typically exhibited greater instability in their export prices, quantities and proceeds; that the causes were inextricably linked to structural parameters concomitant with being 'underdeveloped'; and that the consequences were serious for their development prospects. For example:

> ...."the prices of primary products are notoriously volatile, and the damaging effects of this volatility on the economies of the exporting countries are beyond question." (Cairncross 1962,213)

Similar views were to be found in most development textbooks.[3] Moreover, the consequences here referred, not so much to the instability of consumer or producer purchasing power per se, so much as to the difficulty of achieving a steady foreign exchange stream necessary for development planning. Precisely what constituted 'instability' was not clear, but it was felt that some kind of variance measure representing annual deviations from trend would suffice to capture its essential features.

This 'pessimistic' view emerged as a rather ad hoc synthesis of three strands of literature. The first reflected a trade-cycle scenario strongly influenced by the dislocation of international trade in the 1930's and immediate post-war period. It hypothesised that instability was transmitted through the industrial countries' business cycles to the 'peripheral' economies through import demand. For a treatment of this 'Transmission Hypothesis', see Rhomberg (1968).

The second strand stemmed from traditional price theory, and suggested that instability resulted from specialization on primary exports which were peculiarly susceptible to shifts in supply and demand and were more price inelastic than manufactured goods. In addition, commodity and geographic concentration prevented LDCS from 'gaining on the roundabouts what they had lost on the swings', i.e. balancing losses in one market or commodity with gains in another. An application of a linear partial equilibrium price model to this problem was presented by Massell (1970).

The third strand derived from the infiltration of 'structuralist' insights into international trade theory associated with the so called 'New Trade Theorists' around 1964. For a discussion of this development see Meier (1968), or more recently, Diaz-Alejandro (1972). As well as the market instability and structural inertia characteristics of

LDCS, they stressed the additional element of uncertainty which fluctuations introduced into the calculations of predominantly export-dependent economies. Export instability thus provided another warning against specialization according to the principle of comparative advantage.

The upshot of these arguments was the association of a number of costs with export instability. In the private sector, for example, there might be unstable incomes and frictional unemployment or alternate over and under utilization of capital capacity. However, once again, most emphasis is placed on the development opportunities foregone to achieve external balance in response to fluctuations. For instance, the administrative costs of import controls or the opportunity costs of holding additional reserves to cushion swings in exports. Also important is the effects of instability on the quality and quantity of investment. If uncertainty about receipts encouraged risk-averse behaviour then this might be detrimental to both private and government investment planning. In the agricultural sector, for example, it might discourage diversification from subsistence into risky, but highly profitable, crops.

Hence, the claim that export instability constituted a serious problem for LDCS seemed clear and indubitable to its proponents. Moreover, some early evidence appeared to support their contention that primary commodities were significantly more unstable than manufactures: the United Nations (1952,1953); the International Monetary Fund (1960); and Ady (1969).

However, in the first comprehensive attempt to examine the consequences of unstable exports, MacBean (1966) found little evidence to support the pessimistic case. He found no relationship between fluctuations in export proceeds and fluctuations in national income, investment, prices, or the quantity of foreign reserves; although there was a positive connection with imports[4]. Developing countries with relatively unstable receipts did not invest less, and instability was not related to the ratio of construction investment or stocks to total investment, or to the marginal capital-output ratio. The only glimmer of support for the pessimistic case was the discovery of a weak inverse relationship with the rate of growth of gross national product, and a positive link with the average rate of increase in domestic prices.

In short instability did not, in general, matter enough to merit blanket remedial action. MacBean's explanation for his findings was that specialised countries specialised on relatively stable goods, and instability could be better explained by 'local' causes such as political instability. Moreover, instability was not fully transmitted to domestic variables because of offsetting national policies and low values for the trade multiplier - principally due to a high marginal propensity to consume imported consumer goods by high income groups. Emphasis is thus placed on 'natural stabilizers' which insulated the domestic economy from the impact of fluctuations through cuts in 'luxury' imports, and the absorption of variations within expatriated profits, rather than in employment or taxes.

MacBean's work confirmed the suspicions of people such as Caine (1954,1958,1966) and Hirschman (1959) who recognised that the problem might require action in some cases, but that it need not necessarily be inimical to growth and welfare. On the contrary, instability might be positively associated with growth if investors prefer fluctuating returns with high stakes, and consumers and governments provide for fluctuations through some form of permanent income behaviour or forward markets. Consequently, private adjustment might be optimal in a growth context if, for example, the savings rate were increased. MacBean (1966) and Coppock (1962) also cast doubt on the view that primary commodities were more unstable than manufactures, or that LDCS suffered significantly larger fluctuations in exports than developed countries (DCS). Work by Mathieson and McKinnon (1969,1972) also failed to confirm the Transmission Hypothesis that the post-1945 international economy exerted a net destabilizing impact on LDCS. Although LDCS have been more unstable, they point to more indigenous sources of instability.

(2) Recent work

MacBean's pioneering study stimulated a number of empirical contributions, but surprisingly little theoretical work of direct relevance to the debate above. The major focus has been on applying the static neoclassical market framework to assess the welfare implications of price instability for consumers, producers, and society as a whole; often as a basis for evaluating proposals to stabilize international commodity markets. For a review of the main conclusions, see Wilson (1977a).

An alternative approach was suggested by Katrak (1973) and qualified by Lawson and Theobald (1976). Probability analysis is used to emphasise the importance of ascertaining the magnitude and nature of the adjustment costs implied by different types of fluctuation if one is to assess the net impact of policies on decision-makers.

Diversification may reduce the amplitude of fluctuations in export proceeds, but simultaneously increase their variance.

The necessity to specify *a priori* what type of fluctuations are relevant to decision-makers is also stressed by Gelb (1976) using spectral analysis. The early debate identified instability rather casually with short-run deviations from some long-run trend, but this presupposes a decision has been made as to the type of fluctuations relevant and hence what index we choose to filter out corresponding movements in the time-series.

Research on the empirical front invariably adopted MacBean's (1966) cross-section methodology. Kenen and Voivodas (1972) replicated most of MacBean's results for his time period but discovered a strong inverse relationship between instability and the level of investment for a later period. Further evidence of the harmful effects of export instability was supplied by Glezakos (1972) with respect to both the real per capita growth of gross domestic product, and the rate of growth of exports. Massell and Pearson et al. (1972) focused directly on the structuralists' hypothesis that foreign exchange availability in LDCS constrained imports of 'essential' inputs and hence investment and growth. They disaggregated the foreign exchange market and found support for the hypothesis.

The inconsistency of the cross-section results is reinforced by case-studies. MacBean (1966) argued that Uganda, Tanganyika, Puerto Rico, Chile, and Pakistan displayed no serious ill-effects from export-instability *per se*. This reinforced his conviction that economic instability generally results from non-economic factors. His findings on Chile conflict with Reynold's (1963) earlier analysis which suggested that instability was transmitted from copper export earnings to the domestic economy through destabilizing government spending which varied directly with the cycle and tax receipts. Although expatriate firms appeared to behave in accordance with MacBean's damped multiplier hypothesis, the government's role in transmitting instability would appear to support the pessimistic case. MacBean, however, argues that this may have been exaggerated. Lim (1972) carried out a direct test of MacBean's model for Malaya and, despite a positive relationship between variations in export earnings and gross national product, his study confirms MacBean.

Finally, in an attempt to apply more sophisticated econometric techniques, Rangarajan and Sundararajan (1976) tested a simple structuralist model on a cross-country basis. They found export and investment multipliers to be significantly larger for LDCS, particularly in the medium and long-run. In addition, a comparison between simulation runs for ex-post fluctuations in exports and a steady-state export growth path, revealed a significant link between export instability and fluctuations in gross national product for half of the sample.

(3) Evaluation

The textbook conventional wisdom on the consequences of export instability has been strongly influenced by MacBean's essentially negative findings.[5] However, we shall argue that this was a premature view, and that the problem has not been satisfactorily formulated or tested. This stems from a failure to demarcate and test the null hypothesis that instability matters; from the overwhelming reliance on an inappropriate cross-section methodology; and from the neglect of a rigorous treatment of behaviour under uncertainty; despite the fact that it was a crucial dimension of the problem as envisaged by the structuralist school. We shall complete our evaluation of the literature by emphasising three problems: the statistical problem, the identification problem, and the problem of uncertainty.

The statistical foundation of the export instability literature is open to serious doubts and is complicated by the lack of comparability between the studies with regard to sample, time period, and instability measure. Moreover, confidence that more research along these lines will produce greater consistency is not increased when one considers how easy it was for Sundrum (1967) to reverse nearly all of Coppock (1962) and MacBean's (1966) results and show their sensitivity to the choice of instability index. Similarly, both Maizels (1968) and Ady (1969) were strongly critical of the statistical basis of MacBean's findings.[6]

Despite these early reminders, the mistakes pointed out in these studies subsequently re-appeared with alarming regularity. Pitfalls arising from measurement error, time-period and sample, aggregation, and unit standardisation, have been dealt with in more depth in Wilson(1977b) ; but the key problems surround the instability indexes[7]. Typically, annual deviations in export price, quantity, or proceeds are taken from a linear or log-linear time trend and averaged over 10 to 15 years to arrive at an instability value for one country. This is then listed with similar values for a sample of countries to generate a variable or index of instability. Corresponding indexes for such things as national income or investment or rates of growth of these variables, are then regressed on this index.

Detrending is necessary to prevent a constant increase or decrease being misinterpreted as indicative of instability, but can one seriously assume a unique method of trend correction adequately captures the experience of all of the countries in the sample over the time period? If not, then how does one interpret the value for a particular country? There is considerable danger of missing the subtlety of the transmission mechanism involved.

In view of the proliferation of these indexes (see APPENDIX I), each generating a different set of residuals, the problem of comparability between studies is compounded. To date there has been little systematic attempt to compare indexes over period and sample, although Sundrum (1967) and Lawson (1974) suggested the choice of index does matter. Gelb (1976) also shows quite clearly the highly arbitrary nature of these indexes. The problem of the cross-section approach is that, by definition, it is attempting to summarise all the information in a time-series into a single measure to extract the 'average' experience of the sample, but the cost in terms of insensitivity to the problem in hand may be quite considerable.

The second problem refers to the difficulty of identifying the results of the cross-section studies in terms of the hypotheses under test. The implicit assumption of a unique relationship between export fluctuations and growth across the sample is in danger of 'aggregating the problem away' if countries adjust differently to such fluctuations. Yet it is clear from (1) that MacBean and the 'structuralists' have different types of economy and adjustment process in mind. MacBean implicitly utilises a Keynesian income adjustment mechanism for the balance of payments and a colonial structure based on Levin (1960) characterised by a large expatriate sector, ample foreign exchange reserves,[8] and a government which responds passively to variations in export-revenue. The structuralist school, however, envisaged an economy in which the balance of payments exerted a serious constraint on growth via the supply of foreign exchange needed to finance 'essential' capital imports to a rapidly growing import-substituting sector. A priori, automatic stabilizers of the form envisaged by MacBean are weak.

Also inappropriate here is the use of a static framework for an essentially dynamic issue. The structuralist case was firmly-rooted in a dynamic trade-growth tradition associated with people such as Chenery (1961) who explicitly denied the relevance of the neoclassical framework for LDCS[9]. Hence, the logical outcome of the early debate should have been a dynamic approach building on the short-run cyclical bias of the Transmission Hypothesis and modified where appropriate to reflect structuralist assumptions[10]. However, the structuralists have been more concerned with setting up growth models than formulating the particular problem of export instability, indicating its position within the dynamic allocation problem, and defining the precise links between short-run fluctuations and growth.

What is perhaps needed is to conceive the problem as a complex multiplier process, which necessitates the specification of a set of hypotheses about how fluctuations originating in the export sector are transmitted through the economy, depending upon the particular structure of the economy and the behaviour embodied in the equations of the model[11]. For example, MacBean assumes the government reacts passively to fluctuations in its revenue but ascribes instability to 'political' factors. Surely one cannot so casually dismiss the government as an exogenous cause of instability without looking more closely at its <u>net</u> effect in amplifying and dampening instability; especially in view of the increased range of macro-tools available to post-1945 governments in LDCS in contrast to the colonial era.

This view of the problem will require a more explicit linkage between the Transmission Mechanism (TM) and economic theory than has so far been the case. For example, with respect to the reserve demand behaviour of developing countries, there is a yawning gap between its treatment in the context of export instability and in mainstream economics. In the latter studies hypotheses are carefully derived from relatively sophisticated models and the results consistently show export fluctuations to be an important explanatory variable in sharp contrast to the former studies based upon a much more ad hoc analysis. For a review of the mainstream developments in the demand for reserves literature, see Williamson (1973). For a criticism of the export instability literature in this respect, see Wilson (1977b).

The third problem is perhaps the most serious of all and centres on the question of the uncertainty generated by export fluctuations. Although clearly an important component of the pessimistic view expounded by people such as Nurkse (1958), and raised in a path-breaking article by Brainard and Cooper (1968) in the form of a Markowitz-Tobin portfolio model of international trade; it has been seriously neglected both in theoretical and empirical work. Its welfare and resource allocation effects were ignored through the guise of a risk-neutrality assumption in the neoclassical price framework. Similarly, in empirical work, the costs attributed to uncertainty were dealt with in a very limited manner. Fluctuations are considered 'excessive' in so far as they exceed the minimum necessary to ensure the smooth adjustment of supply and demand over time, and hence give perverse signals to decision-makers. But in the empirical work when fluctuations in, say, investment are related to fluctuations in exports, what is being tested is the hypothesis that there are costs attached to the adjustment of actual to optimal capital stock against the alternative that these costs are so heavy as to preclude complete adjustment in each time-period. But if investors are risk-averse then there may be no correlation between the two variables, but instead a reduction in the quantity of investment or portfolio diversification into less risky but lower yielding projects. In this case, policies to reduce risk-averse behaviour might raise investment and growth.

The literature, therefore, has relied upon a simplistic 'Pavlovian' adjustment mechanism and has ignored the possibility of more subtle behaviour in the face of uncertainty and hence of a correspondingly more complex multiplier process. It is in this sense that the proliferation of instability indexes becomes important, since it presumes that a decision has been made a priori as to the type of fluctuations which are relevant to decision-makers, and hence which movements we select to filter out of the relevant time-series.

A number of pertinent general remarks arise from this brief review of the literature on the consequences of export instability. The early debate tended to exhibit a lack of theoretical clarity, so that the 'pessimistic' case emerged as a rather unsatisfactory synthesis of a cycle theory, a traditional market model, and a structuralist protest. The first was subsequently neglected, the second imparted an unnecessary static bias to research; and the third remained an offshoot of a more general debate and was never adequately formulated, particularly the precise link between the short and long run consequences of export fluctuations.

Scepticism of the pessimistic case led to the healthy formulation of alternative hypotheses about how fluctuations were transmitted from the export to the domestic sector - notably MacBean's damped multiplier thesis. This served to force the debate into a more empirical mould; but MacBean's findings exerted an unwarranted impact on the textbook interpretation of the problem and subsequent research was hindered by three sources of confusion.

Firstly, the adoption of a static, highly aggregative, cross-section and crude multiplier analysis, lacked the degree of sensitivity required for the problem and is fundamentally in conflict with the conception of the TM as a dynamic process. This does not, of course, deny the usefulness of these methods, but only that the results have not been encouraging and a change of course might be required. Secondly, there has been a failure to clearly specify the TM assumed and to relate it to testable structural and behavioural hypotheses grounded in economic theory. And finally, the testing of the null hypothesis that instability matters has been delayed by the absence of an explicit theory of uncertainty and a clear specification of the costs of adjustment resulting from export fluctuations.

1.2 Export Instability and Post-War Ghana

This section is set aside for some general background material on post-war Ghana, and a description of the methodology employed in the thesis. In (1) we sketch in the most important features of the economic history of Ghana during the period. In (2) we briefly justify the choice of Ghana as a case-study; and in (3) we explain the basic methodology used in subsequent chapters.

(1) Some historical background

From 1950 to 1957 Ghana experienced a period of quasi-independence after over a century of British colonial rule. It was characterised by growing autonomy in domestic affairs but total reliance on Britain for foreign policy. Economic policy was essentially laissez-faire with government intervention limited to infrastructure and social policy. Macroeconomic policy consisted of balanced-budgets, a passive monetary policy under a sterling exchange standard, and absence of a central bank. This period is, however, noted for the absence of inflationary pressures or balance of payments disequilibrium and buoyant world prices for Ghana's major export - cocoa. The result was the accumulation of sterling reserves and an average real growth rate of around 5% per annum between 1955 and 1960[12].

In 1957 Ghana was granted independence and full national status within the British Commonwealth but retained a ceremonial Governor-General with nominal powers up to 1960. This was followed by a period of Socialist Republicanism involving a highly centralised administration and a single-party system. Under the President, Nkrumah, economic policy was strongly interventionist and committed to planned rapid industrialisation and a package of socialist welfare objectives based upon an import substitution strategy. A Central Bank and a national currency were introduced in 1957. Macroeconomic policy was of a stop-go variety, reflected in budget deficits and financed through increases in the money supply. The outcome was persistent inflation and under-utilisation of capacity, often due to shortages of imported spare parts and poor investment policies (See TABLE 1.1).

	1956	1957	1958	1960	1964	1967	1968	1969	1970	1958/9 to 1964/5	1964/5 to 1968/9	1958/9 to 1968/9
(1) Real private consumption per capita (1960=100)	94			103	93	84						
(2) Consumer price indices (1960=100)			96	100	134		189					
(3) The growth of consumer prices (1960=100)		.94		.92	11.8	8.5						
(4) The unemployment rate (%)	9.8			6	3.4		13.5		6.3			
(5) Real output per employed worker (1960=100)	347			372	364	355						
(6) Debt service payments[1]						19	36	30				
(7) Real per capita GNP growth per annum (%) (1960=100)										.2	-2.3	-.8

Sources : (1), (3), (5) Merritt-Brown (1972) table 1.1.
(2), (6), (7) Killick (1978) tables 4.c, 5.4, 4.1.
(4) Merritt-Brown (1972) and Killick (1978).

1. This includes principal plus interest payments in millions of cedis. see Killick (1978,113).

TABLE 1.1 Some key statistics for the Ghanaian economy in the post-war period

Growth stagnated, was highly unbalanced in favour of industry; and total per capita consumption fell, despite the offsetting provision of more social services. Export receipts plummeted in the face of secularly-declining terms of trade[13]; and the failure of state intervention to raise productivity in agriculture and industry resulted in the depletion of foreign exchange reserves, an increase in debt-service ratios, and the increasing use of tariffs and controls on imports (see TABLE 1.1).[14]

Events came to a head in 1966 when the military overthrew Nkrumah and placed in power the National Liberation Council (NLC). This government was subsequently replaced by a civil alternative under Kofi Busia in September 1969. Nkrumah's successors embarked upon a policy of liberation of controls and the achievement of internal and external balance, but it appears that in practice the NLC was more of a continuity than a radical change.[15] Few of the underlying problems were tackled and, as with Nkrumah, there was a reluctance to work within the constraints imposed by foreign exchange reserves, savings, and government revenue.

(2) Ghana as a case-study

Ghana was selected for this thesis for four major reasons. Firstly, stability and growth were heavily dependent on the production and export of a single primary commodity - cocoa - whose price has been historically unstable.

Secondly, Ghana exhibited many of the features of a 'structuralist' economy in the 1960's after she had depleted her surplus of foreign exchange reserves. Since much of the analysis in subsequent chapters revolves around the concept of structuralism, it is perhaps pertinent at this juncture to briefly elaborate on its essential features and on its relevance to Ghana, both as a description of the economy and as an influence on policy formation in the 1960's.

Structuralism has its roots in the post-1945 development literature which protested against the uncritical application of traditional neoclassical economic theory to the development problem. See Killick (1978). It conceived of development as a discontinuous process of structural change requiring a 'big push' in investment to escape from 'vicious circles of poverty' and attain self-sustaining growth, usually assumed to be synonomous with industrialisation.[16] Allied to this was the adoption of an 'inward-looking' international trade policy of import-substitution and protectionism influenced by Chenery's (1961) denial of the relevance of conventional comparative advantage theory to the developing countries,[9] and a growing pessimism about the prospects for primary exports, later synthesised in the United Nations (1964). We indicated in our review of the literature the influence of these 'New Trade Theorists' on the export instability debate, through their stress on the structural inertia and market instability characteristics of LDCS, and their identification of the potential costs of uncertainty generated by fluctuations in the revenue of export-dependent economies. But another important dimension of the structuralist approach, of particular relevance to Ghana in the 1960's, is the conception of the balance of payments as a binding constraint on growth via the supply of foreign exchange needed to finance 'essential' imports for domestic industrial expansion. The rationale behind this is derived from 'two-gap' analysis.

Two-gap analysis has its origins in the standard Keynesian position that while the savings-investment gap and export-import gap are identical ex post, there is no reason to expect them to be equal ex ante. When a shortage of domestic savings is the more important problem, the savings-investment gap will ex ante be the larger; when foreign exchange is the constraint, the ex ante export-import gap will be the greater. The role of foreign resources is then to fill the larger of the two gaps. Models were then constructed to estimate the required level of foreign resources (including aid) given a target growth rate and assumptions about savings, investment,exports and imports. Usually this involved an accelerator theory of investment, a Keynesian savings function, an exogenously-determined export function, and import equations which distinguished between consumption goods and capital goods. In the absence of a domestic capital goods sector, a minimum level of 'essential' imported capital goods would be required to sustain growth. For a survey of these models, see Diaz-Alejandro (1972).

The implication of this approach is that growth may be constrained either by savings or foreign exchange and that foreign resources will usually be needed to supplement domestic savings if target growth rates are to be achieved. The corollary is that if foreign exchange is the binding constraint, then raising the domestic savings rate will be essentially futile, since the resources released will remain idle in the absence of cooperating factors from abroad. Policy may then be directed to reducing 'luxury' imports and providing protection to 'infant' import-substituting industries; although export promotion is an alternative strategy.

It is perhaps to be expected that these models would be received with some suspicion by neoclassical trade theorists, but Findlay (1973) has done much to reconcile the two approaches within a micro-theoretic framework. Two-gap analysis is more persuasive to the extent that price-adjustment, for example via the exchange rate, is limited, and rigidities of the sort assumed in their models apply in reality to particular LDCS. In particular where the prospects for expanding traditional exports are weak, domestic investment depends in a fixed way on imported inputs, and the elasticity of substitution between domestic and imported inputs is close to zero. If these assumptions are valid, then a government committed to a particular growth target may see no alternative but to adopt an inward-looking trade policy. The appropriateness of the given growth rate is, of course, itself open to question.

There is little doubt that Ghana exhibited many of the features of a structuralist economy in the 1960's and this will be reflected in our modelling of the economy in chapters 2 and 3. In the first place, Ghana depended heavily for foreign exchange and government revenue on cocoa, the long-run prospects for which appeared pessimistic; while diversification into other export lines would take some considerable time. In chapter 2 we shall elaborate on the structural features of the cocoa market and the relationship between instability and uncertainty. Secondly, growth was dependent on the ability to sustain imports of raw materials and capital goods, given the high import content of domestic capital formation.[17] In 1960 Ghana was almost wholly reliant on imports for all types of capital goods except construction materials. See Killick (1978). Consequently, given the government's committment to rapid, centrally planned, industrialisation; there was likely to emerge a gap between export earnings and import demand unless filled by foreign resources, since by 1960 the stock of foreign reserves accumulated earlier had been depleted. Confirmation that it was the foreign exchange constraint which was the binding constraint is provided by Killick's econometric examination of the two-gap model from 1960 to 1969. See Killick (1978).[18]

There is also little doubt that the structuralist literature influenced Ghanaian policy in the 1960's. See Killick (1978). A policy of diversification into industrial goods and the relative neglect of agriculture and cocoa production was justified in terms of pessimism about the prospects for continued reliance on unstable cocoa export receipts. An inward-looking trade policy was adopted on the grounds that insufficient foreign exchange was likely to be available to finance the essential imports required by domestic industry. The increased role of the state in the economy was a response to the perceived magnitude of the big push development task, the scarcity of industrial entrepreneurs, and a committment to socialism. One cannot, therefore, comprehend the performance of the Ghanaian economy, explored in subsequent chapters, without an understanding of the structuralist context within which it took place.

Thirdly, although Ghana has often been cited as a classic instability case, this is not reflected in the rankings of export revenue instability indexes from cross-section studies. TABLE 1.2 presents some of the instability

PERIOD	VARIABLE	INDEX [2]	MAGNITUDE	RANK [3]	STUDY SOURCE
1953-1966	price [1]	OLS	15.52	1/27	Glezakos (1972)
	quantity	linear	8.89	13/27	"
	revenue	"	8.65	21/40	"
1946-1958	merchandise revenue	log variance	52.4	15/61	Erb and Schiavo-Campo (1969)
1954-1966			10	47/66	"
1946-1958	goods and services	"	31.9	9/37	"
1954-1966	revenue	"	15.5	10/39	"
1950-1959	revenue [1]	OLS	9.9	31/42	Erb and Schiavo-Campo (1971)
1960-1968		linear	5.9	30/42	
1950-1959		OLS	10	40/55	"
1960-1968		exponential	5.9	39/55	"
1950-1959	Merchandise revenue	"	.096	27/45	Lawson (1974)
1960-1969		"	.0618	27/45	"
1950-1959		OLS	.1108	26/45	"
1960-1969		linear	.066	29/45	"

Notes : 1. It is unclear whether services are included.

2. See APPENDIX I..

3. A ranking of 1 would represent the highest degree of instability in the sample of developing countries.

TABLE 1.2 : Some selected export instability indices for Ghana

indices for Ghana computed from these studies. Some problems associated with them have already been raised in 1.1 and APPENDIX I provides more details on their construction. This paradox will be explained by examining more closely the mechanism by which fluctuations are transmitted through the economy allowing for the complicating presence of a marketing-board system. Ghana illustrates how the consequences of export instability depend not only on the magnitude of export fluctuations, but also on the behaviour of key 'actors' or decision-makers within the TM such as cocoa farmers and the government. Finally, and not least important, is the availability of a consistent set of national accounts by the standards of the developing world, suitable for the construction of a macroeconomic model. There are, of course, difficulties with this data (discussed in Chapter 3), including the restriction of the model to the period 1956 to 1969. Some attempt, however, is made within the model specification to overcome the sort of discontinuities referred to in (1) above.

(3) A time-series simulation approach

The principal objective of this thesis is to formulate the problem of export instability as a dynamic TM, emphasising the interdependence between sectors of an economy and the importance of specifying how key 'actors' adjust to fluctuations. We will first expound the basic idea of the TM; then extend it to incorporate uncertainty; and finally, justify the use of simulation in this context.

If the problem of export instability is seen as a dynamic one, where the consequences depend upon the structure of the economy and the behavioural adjustments made to fluctuations; then the onus is upon the researcher to construct a time-series model which reflects, as far as possible, the structure of the economy, and embodies within its equations a particular set of hypotheses about the transmission of fluctuations from the export to the domestic sector. Since each economy is, to some extent, structurally unique, and the range of possible hypotheses about adjustment behaviour is wide, the propensity for variation is enormous. This approach does, however, force the investigator to clearly demarcate his view of export instability and explain its derivation from economic theory. Optimistically, there may be a potential for greater generalization if economies display similar structural characteristics.

FIGURE 1.1 illustrates some of the general questions which arise when considering the specification of such a model. A starting point is likely to be the sectoral composition of the economy:- its import and export mix; the relative importance of industry and agriculture; and intersectoral linkages, including government dependence on revenue from the export sector. Then one might want to examine the 'primary' multiplier effects of changes in the various types of export receipts, depending both on the magnitude of variations, and on the significance of private and government 'automatic stabilizers'. For example, compensatory changes in expatriated profits or luxury imports. The secondary effects on non-export transactors may, therefore, be quite different to the primary effects on exporters. Moreover, the eventual impact upon the domestic economy, both in terms of short-run cyclical movements, and longer-run growth effects, will also depend upon the hypotheses embodied in the behavioural equations. There will be the obvious

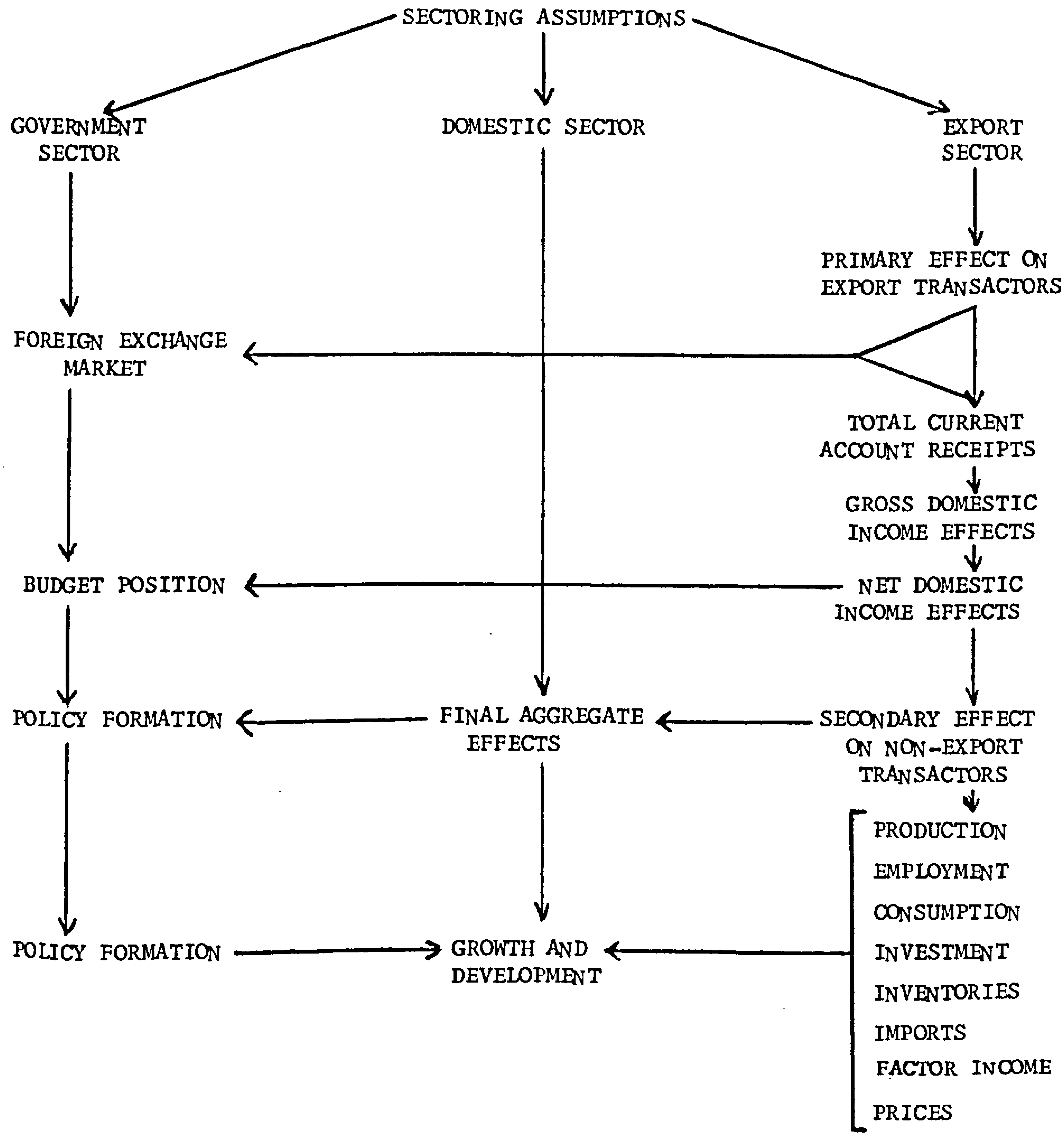

FIGURE 1.1 The transmission mechanism

import and consumption multiplier effects; but also more subtle relationships between, for example, domestic industry and 'essential' imports of machines and raw materials, or between government spending and changes in its revenue and in its foreign exchange balance.

FIGURE 1.1 should not be interpreted as implying causality, but only as suggestive of the sort of considerations which might arise in the construction of a particular model, and as an aid to comparing different TM's. One might explore, for instance, the differences between a 'classic' MacBean colonial economy and an ideal-type structuralist one[19].

In the case of Ghana, the basic structural features of this economy are heavy dependence for both foreign exchange and government revenue on one primary export - cocoa; a small but rapidly growing import - substituting domestic manufacturing sector with negligible direct linkages with cocoa or domestic agriculture, but indirect dependence on imports of capital goods and raw materials; and a government committed to rapid, centrally planned, industrialization.

Fluctuations will be traced from an independent cocoa subsector set up in chapter 2, to a macroeconomic model of Ghana derived and estimated in chapter 3. The effects will be gauged on the components of aggregate demand; on output, employment and factor income; on the government; and on prices.

This is the underlying perspective of the TM, but we need to extend it to cover the concept of uncertainty. In order to investigate the possible effects of uncertainty on an economy such as Ghana generated by export fluctuations, and to define the particular theory of uncertainty adopted in this thesis, we will now consider a simple aggregative model. An input-output framework is used because it facilitates aggregation and it emphasises sectoral interdependence.[20]

Assume an economy which produces a range of commodities including exports and imports, and is a price-taker. Further assume an aggregate utility function dictating that the economy maximises the short-run expected utility of net returns, measured arbitrarily in terms of foreign exchange. The use of the expected utility approach recognises that in the real world decisions are made under uncertainty, where the choice relates to a random variable or random stream of returns the outcomes of which are not, a priori, known. However, if decision-makers attach subjective probabilities to the possible values of the uncertain variables, then risk analysis can be used once appropriate assumptions have been made about decision-makers' attitudes to risk. The expected utility approach has now been applied in many areas of economics, notably in investment theory and the theory of the firm; but it remains to be widely diffused into trade theory, despite a pioneering work by Batra (1975).

Following Von-Neumann and Morgenstern (1947), let the attitudes to risk in this economy be defined by the following utility function:

$$U = U(\pi)$$

where: π = Net earnings in foreign exchange

This function is concave, continuous and differentiable:

$$U'(\pi) > 0; \qquad U''(\pi) < 0$$

where: ' = The first derivative

'' = The second derivative

Hence the utility function incorporates the assumption of risk-aversion.

Define an aggregate cost function implying constant marginal costs

$$C = q^{*}Ap + Co$$

$$\frac{\partial C}{\partial q_i} > 0; \quad \frac{\partial^2 C}{\partial q_i^2} = 0 \text{ for all } i$$

Where:

C = Total costs

q = A vector of gross output

p = A vector of world prices

$A\ (a_{ij})$ = A matrix of input-output coefficients representing the physical inputs of commodity j for unit output of commodity i

$*$ = The transpose of the argument

Co= Costs independent of variations in p

If $\pi = q^* p - C = q^* p - q^* A p - Co$

or $\pi = q^* (I-A) p - Co$

Where I is the identity matrix. Then, letting $B = I-A$

$$\pi = q^* B p - Co$$

The problem is to choose q to maximise expected utility:

$$E \left[U \left(q^* B p - Co \right) \right]$$

with the first-order condition:

$$\frac{\partial E(U)}{\partial q} = E \left[U'(\pi) \left[B p - Co' (q) \right] \right] = 0$$

or $$\frac{\partial E(U)}{\partial q_i} = E \left[U' (\pi) \left[\phi_i p - Co' (q_i) \right] \right] = 0$$

for $i = 1, 2, \ldots, n$

where: ϕ_i = The i'th row of B

The expected utility framework is thus a useful means of introducing uncertainty into a model, but in order to facilitate empirical work, the **mean-variance** (MV) approach was adopted. It is commonly recognised that this approach is consistent with that of expected utility only if all probability distributions are multivariate normal, or the utility function is quadratic. The drawbacks of this methodology have been well documented. In particular, see Rothschild and Stiglitz (1970 and 1971); who also discuss some further desirable properties of utility functions incorporating the assumption of risk-aversion.

Consider, therefore, a quadratic utility function of the following form:

$$U = \pi + \tfrac{1}{2}\delta\ (\pi - \bar{\pi})^2 \quad ; \quad \delta < 0$$

where: π = Actual net earnings

$\bar{\pi}$ = Expected or mean earnings

δ = A risk-aversion parameter

So, given the distribution of expected rates of return and deviations from these rates (or simply returns and risks), aggregate utility is analogous to a choice among a set of feasible investments subject to a utility function which incorporates risk-aversion i.e. preference for expected returns and against the variation of returns, ceteris paribus.[21] Risks arise from unforeseen fluctuations in world prices, costs, etc.

The next task is to introduce uncertainty. Assuming uncertainty only in world prices, p is a vector of random prices with a distribution defined by its expected values (E); the variance of its values (VAR); and the covariance of its values (COV):

$$E\ (p_i) = \bar{p}_i$$

$$VAR\ (p_i) = \sigma_i^{\ 2}$$

$$COV\ (p_i) = \sigma_{ij}^{\ 2}$$

In other words, the country is a price-taker in the probabilistic sense i.e. its output is not large enough to influence its subjective distribution about world prices, and a decision on q has to be taken prior to knowledge of p.

The objective function is to choose q to maximise:

$$\begin{aligned} E(U) &= E(\pi) + \tfrac{1}{2}\ \delta\ E\ (\pi - \bar{\pi})^2 \\ &= \bar{\pi} + \tfrac{1}{2}\ \delta\ VAR\ (\pi) \end{aligned}$$

where:

$$\bar{\pi} = q^*B\bar{p} - Co$$

$$VAR\ (\pi) = q^*B\ T\ B^*\ q$$

T = The covariance matrix of world prices

This function is at a maximum with $q_i > 0$ when:

$$\frac{\partial\bar{\pi}}{\partial q_i} + \delta\ q^*\ (B\ T\ B^*)_i = 0$$

or

[1] $$\frac{\partial\bar{\pi}}{\partial q_i} + \delta q^*\ \psi_i = 0$$

where:

ψ_i = The i'th column of B T B*

A number of implications flow from this model. Firstly, it makes explicit the approach to uncertainty employed in this thesis and the relationship between the MV approach and the more general expected utility framework.

Secondly, it demonstrates the effects of uncertainty on an economy faced with large fluctuations in prices (and can easily be extended to cover random quantities or costs), since only if T = 0 does [1] reduce to the profit-maximizing condition that the 'price' of a process be set equal to marginal cost. Marginal cost less than expected price implies a reduction in the output of risky goods compared to a position of certainty. This provides the grounds for diversification of exports if existing exports are particularly unstable and there are potential alternative export or import-substituting lines which are less risky and also have the negative covariance properties with respect to current exports. This portfolio dimension, involving the choice between a range of feasible outputs, is important; since a decision to produce a particular commodity is rarely taken in isolation, but takes into account the risks and returns of feasible alternatives. Although some attempt will be made in later chapters to allow for these covariance aspects, the data for a detailed analysis is not available for Ghana, and this should be borne in mind.

Thirdly, the model is a guide to the type of uncertainty which might be relevant to particular 'actors' in the TM. For example, cocoa farmers might be more interested in fluctuations in net receipts from their crop than in price per se. This raises the question as to whether there might be a possible divergence between private adjustment to uncertainty and what is socially desirable. For example, exporters may be unable to diversify sufficiently due to lack of resources or information, or not take into account the full welfare effects on the rest of the economy of their own adjustment behaviour. Hence, there might be grounds for policy intervention to guide them to the optimum social allocation of resources as an extension to the theory of externalities. For a discussion of this, see Brainard and Cooper (1968).

We shall conclude this chapter with a brief exposition of the role of simulation in the problem of export instability. In chapter 4 the model for Ghana is simulated over the sample period as an ex post unconditional forecast and the results are evaluated using appropriate 'goodness of fit' criteria. This will enable us to gauge how the 'system' functions as a whole and to compare alternative methods of estimation. In addition, it facilitates 'sensitivity' analysis on the key parameters and provides feed-back information to the original model. This is important since an equation which is a 'good fit' on its own, may not perform well when the model is treated as a whole.

Perhaps the most important justification for simulation here, is that it enables us to calculate multipliers to quantify the impact of exogenous shocks in the export sector on the economy and through stochastic simulation to examine the probability distribution of these multiplier values through replicated experiments. Given a general linear model with G structural equations:

$$Fy_t + \Gamma x_t = U_t$$

where:

F = A matrix of coefficients of current endogenous variables (G by G)

Γ = A matrix of coefficients of predetermined variables (G by K)

U = A vector of G classical error terms

y = A vector of G current endogenous variables

x = A vector of K predetermined variables

$t = 1, 2, \ldots, n$ observations

then the multiplier effect from 'shocking' any predetermined variable :

$$\frac{\partial Y_i}{\partial x_j} = Z_{ij}$$

is derived from the reduced form (assuming F to be non-singular) :

$$Y_t = Zx_t + V_t$$

where : $Z = -F^{-1}\Gamma =$ A matrix of reduced form coefficients (G by K)

$V_t = F^{-1}U_t =$ A vector of G reduced form error terms

Notes

1. This problem is well documented in the various publications of the United Nations. See the United Nations (1979).
2. This review considers only material directly concerned with the effects of export instability. For a more detailed critical evaluation of the subject, including reference to the magnitude and causes of export fluctuations, see Wilson (1977a) and Wilson (1977b).
3. For an early treatment of the problem, see Coppock (1962); or more recently, Helleiner (1972). MacBean (1966) also discusses these views under his 'prima facie' case and was the source of my quotation from Cairncross (1962).
4. MacBean's cross-section and time-series results confirmed a previous study by the United Nations Commission for Latin America (1962). See MacBean (1966,66).
5. For example, Sodersten (1974); and Kindleberger and Lindert (1978).
6. On the general validity of MacBean's findings, Maizels concludes:

   > "The author's attitude toward policy....is heavily influenced by the generally negative results of his statistical analysis....The statistical analysis, which constitutes the core of his book is, however, generally not convincing."

7. A description of some of the more common measures, and the problems associated with them, can be found in APPENDIX I.
8. Ample in the sense that a long-run foreign exchange constraint was not assumed.

9. Chenery (1961) argued from assumptions derived from growth theory, that if LDCS exhibit external economies and a divergence between market prices and social opportunity costs, then the static pattern of allocation dictated by comparative advantage is inconsistent with a pattern which maximises growth.

10. In this case one would not necessarily expect to find a direct relationship between fluctuations in exports and growth but an indirect one through the impact of fluctuations in imports of capital goods on investment.

11. The possibilities for variation here are enormous. See Wilson (1977a).

12. For details on the economic history of post-war Ghana, see Birmingham and Neustadt et al. (1966), and Killick (1978).

13. This is controversial but especially likely between 1960 and 1966. See Killick (1978).

14. For a critique of policy in the 1960's, see Killick (1978).

15. See Killick (1978).

16. Inflation also tended to be regarded as an inevitable, albeit undesirable, symptom of an adequately large development effort.

17. The marginal import component of capital formation from 1955 to 1960 was 44% and the elasticity of demand for imported capital goods with respect to total capital formation was 1.02. Estimates of the income elasticity of import demand for the 1950's (1.2 to 1.7) suggest that import capacity would have to grow considerably faster than domestic incomes if local demand was to be satisfied in line with the 1950's

growth rate of around 5% in real terms or 2.5% per capita. See Killick (1978).

18. On the assumptions that in the short and medium run export earnings are exogenous and that actual investment is equal to ex ante investment, there was a significant negative correlation between savings and foreign capital receipts; but no relationship between these receipts and imports. Adjustment, therefore, was via a reduction in domestic savings below the target level, and foreign resources substituted for savings. The first assumption is probably innocuous for Ghana, but the second is more controversial. For further details on the tests and the second assumption, see Killick (1978).

19. For such an exercise, see Wilson (1977a).

20. The following analysis is based upon Brainard and Cooper (1968).

21. For an application of this perspective within a Markowitz-Tobin portfolio model of international trade, see Brainard and Cooper (1968).

CHAPTER 2 : THE COCOA SUBSECTOR

This chapter seeks to explain the intermediate to long-run price fluctuations in the world cocoa market generated by the interaction of cobweb cycles and annual variations in production, consumption and inventories; and examines their implications for cocoa production in Ghana. Then in chapter 3, the effects of these fluctuations are traced on the rest of the economy.

In 2.1 we consider the nature of the world cocoa market, its importance to Ghana's well-being, its susceptibility to instability, and the most appropriate way to model it in the Ghanaian context. In 2.2 to 2.5 the various components of the model are assembled, including in 2.2 some allowance for uncertainty in cocoa farming. In 2.6 the complete model is summarised. The estimated equations are tabulated in APPENDIX VI and APPENDIX VII; and some problems associated with the data are raised in APPENDIX X.

2.1 The Cocoa Market

(1) The structure of the cocoa market

The importance of cocoa to the Ghanaian economy is shown by TABLES 2.1 and 2.2. Its low absolute contribution to gross domestic product disguises its crucial influence on development through its weight in domestic value-added and as an earner of vital foreign exchange.

The production of cocoa is concentrated in relatively low income countries; with Ghana, Nigeria and Brazil together supplying approximately 63% of the world export market. Ghana's export share has fluctuated around 33% (See TABLE 2.3).Cocoa is a tropical primary product which is relatively homogenous, perishable in tropical climes, and requires fairly specific ecological and climatic conditions.[1]

1960	Labour force %	Gross domestic product %	Foreign exchange %
Cocoa	20.4	10.8	65
Manufacturing	9.1	12.6	
Construction	3.5	4.3	
Commerce	14.5		
Timber			9
Gold			8
Diamonds			4

Source : Manu (1974).

TABLE 2.1 The contribution of cocoa to employment, income and foreign exchange

	(1) Cocoa revenue / government revenue (%)		(2) Share in export earnings (%)
1961	17.6	1957-1961	66
1962	16.4	1967-1971	69.1
1963	17.2		
1964	11.7		
1965	6.9		
1966	6.6		
1967	13.7		
1968	23.4		
1969	29.5		
1961-1969	16		

Sources : (1) Manu (1974).

(2) Singh, De Vries, et al. (1977).

TABLE 2.2 The contribution of cocoa to government revenue and export earnings

	(1) Share of world imports[1] (%)		(2) Share of world production[1] (%)		(3) Share of world exports[1] (%)	
	1957-1961	1967-1971	1957-1961	1967-1971	1957-1961	1967-1971
United States	29.9	24.2				
Fed. Repub. Germany	12.9	12.2				
United Kingdom	11.3	7.8				
Netherlands	9.7	10.2				
Total	63.8	54.4				
Average	59.1					
Ghana			31.3	28.5	35.3	29.7
Nigeria			14.2	17.9	17.5	20.4
Brazil			17.1	22.7	12.8	10.2
Total			62.6	69.1	65.6	60.3
Average			65.9		63	

1. Cocoa beans only.

Sources : (1) Singh, De Vries et al. (1977), Table 28.
(2), (3) Singh, De Vries et al. (1977), Table 24.

TABLE 2.3 The major producers and consumers of cocoa

The production structure is characterised by predominantly small-scale peasant farmers with a hoe and axe technology and modern insecticides. By far the greater part of output enters international trade, and during the period relevant here, output tends to be purchased by marketing boards or other quasi-governmental agencies[2]. Supply price elasticities in the short-run tend to be very low, while long-run values are substantially higher (see TABLE 2.6 below).

The demand for cocoa is a derived demand for cocoa products and is concentrated in high income countries (see TABLE 2.3). This market is dominated by oligopsony and oligopoly[3] and since about 1925 has been organised through a sophisticated set of actuals and terminal markets, with a high proportion of output being sold through futures markets, as a means of bridging the gap between discrete harvests and continuous grinding of cocoa for use in manufactured products[4]. Consumption is also characterised by low price and income elasticities (see TABLE 2.7), the latter reflecting Engel's Law, i.e. an absolute ceiling on consumption per head due to the change in tastes as income rises.

FIGURES 2.1 and 2.2 summarise graphically some key indicators of development in the world cocoa market from 1950 to 1969. Production and export volume grew rapidly in this period at approximately 3.3% and 2.4% per annum respectively. A peak in 1964/5 reflected favourable weather conditions, past plantings (stimulated by high prices in the 1940's and 1950's), and technological improvements, including the replacement of swollen shoot diseased trees by higher-yielding stock and the control of capsid disease by spraying. Consequently, prices plummeted to a record low in 1965. Deficient supply followed for about 4 years due mainly to excess rain and the

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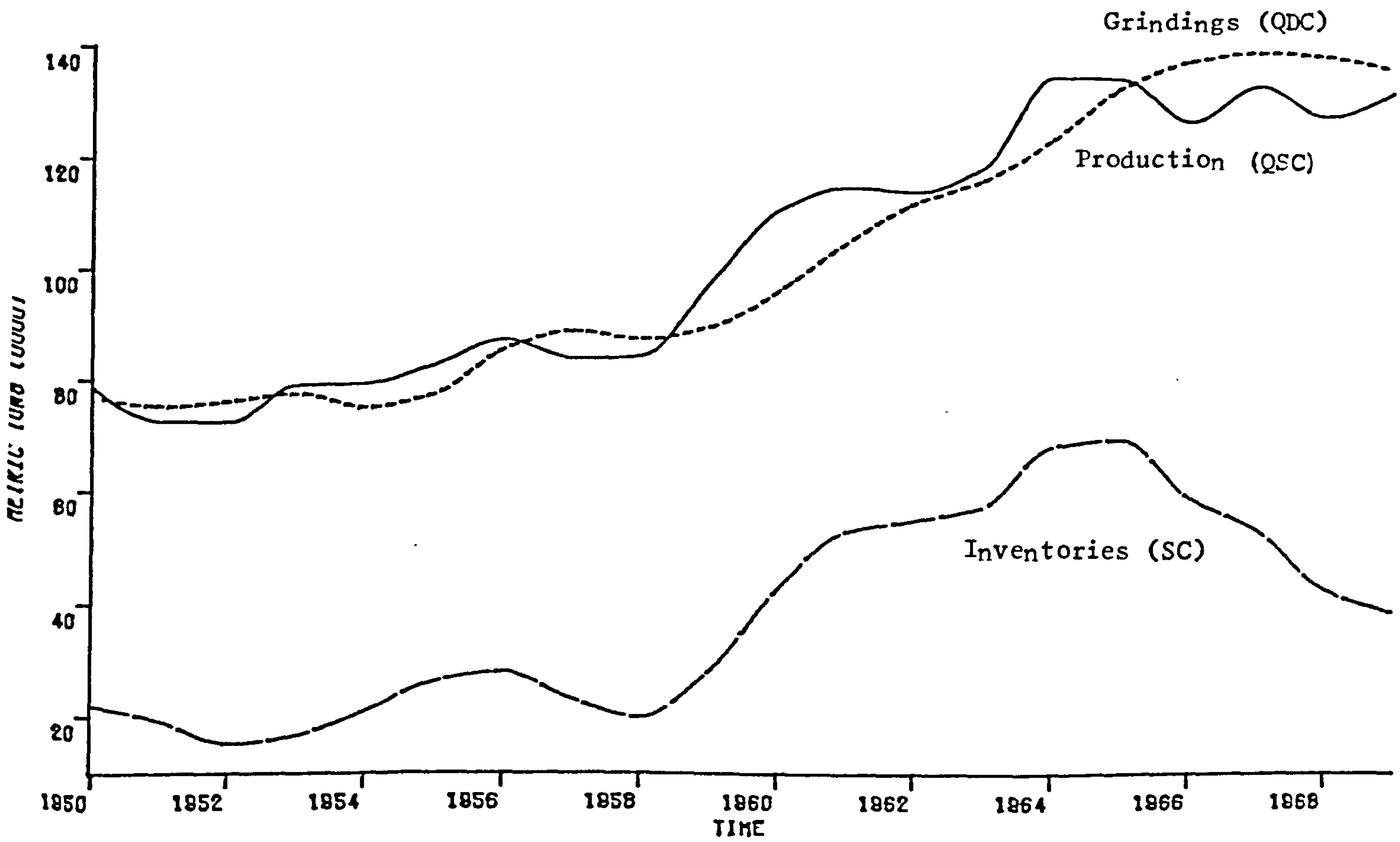
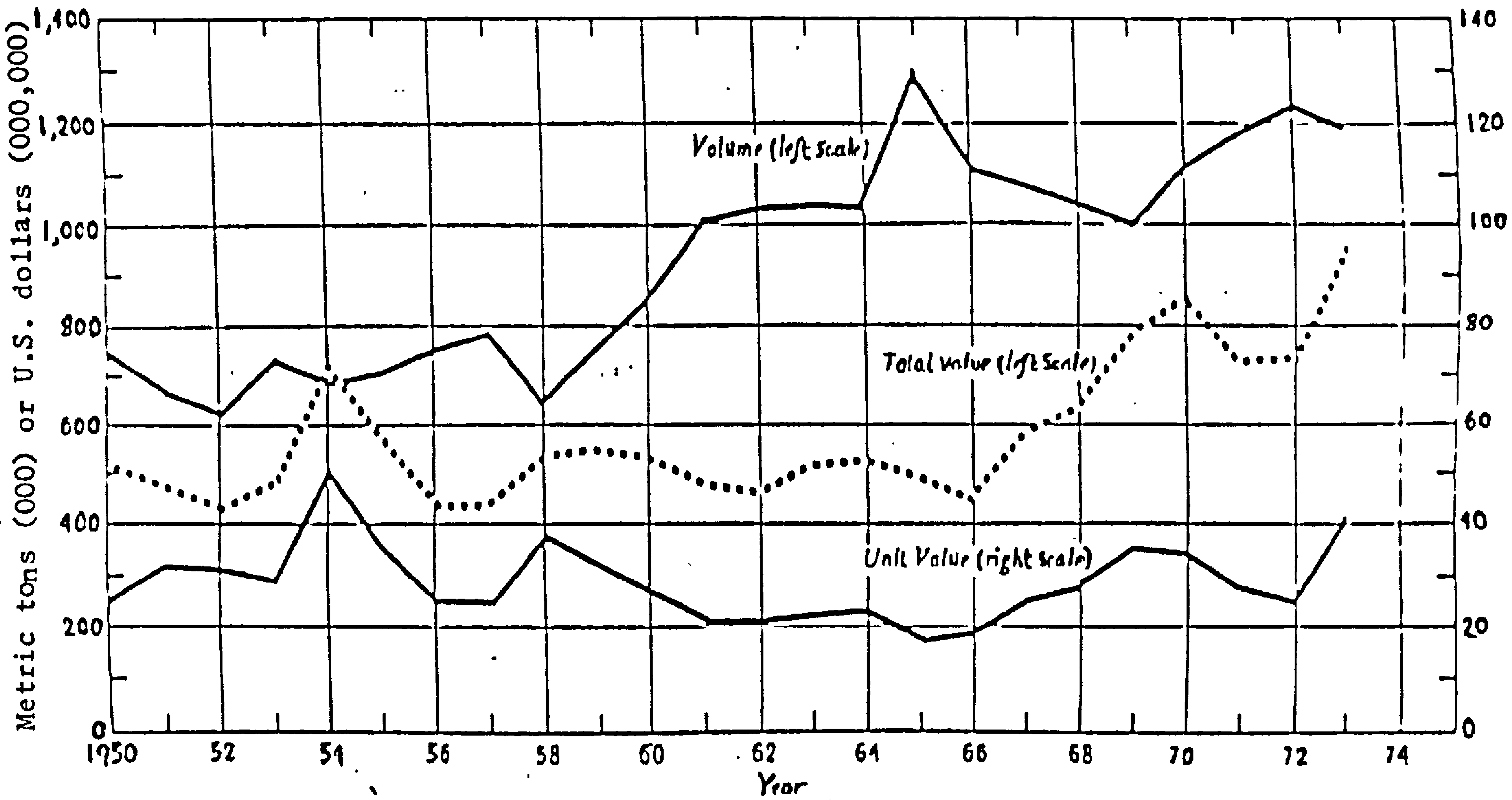


Source : APPENDIX IV.

FIGURE 2.1 Supply and demand in the world cocoa market 1950-1969.



Source : Singh, De Vries et al. (1977).

<u>FIGURE 2.2 Volume, total value and unit value of world exports of cocoa beans 1950-1973</u>.

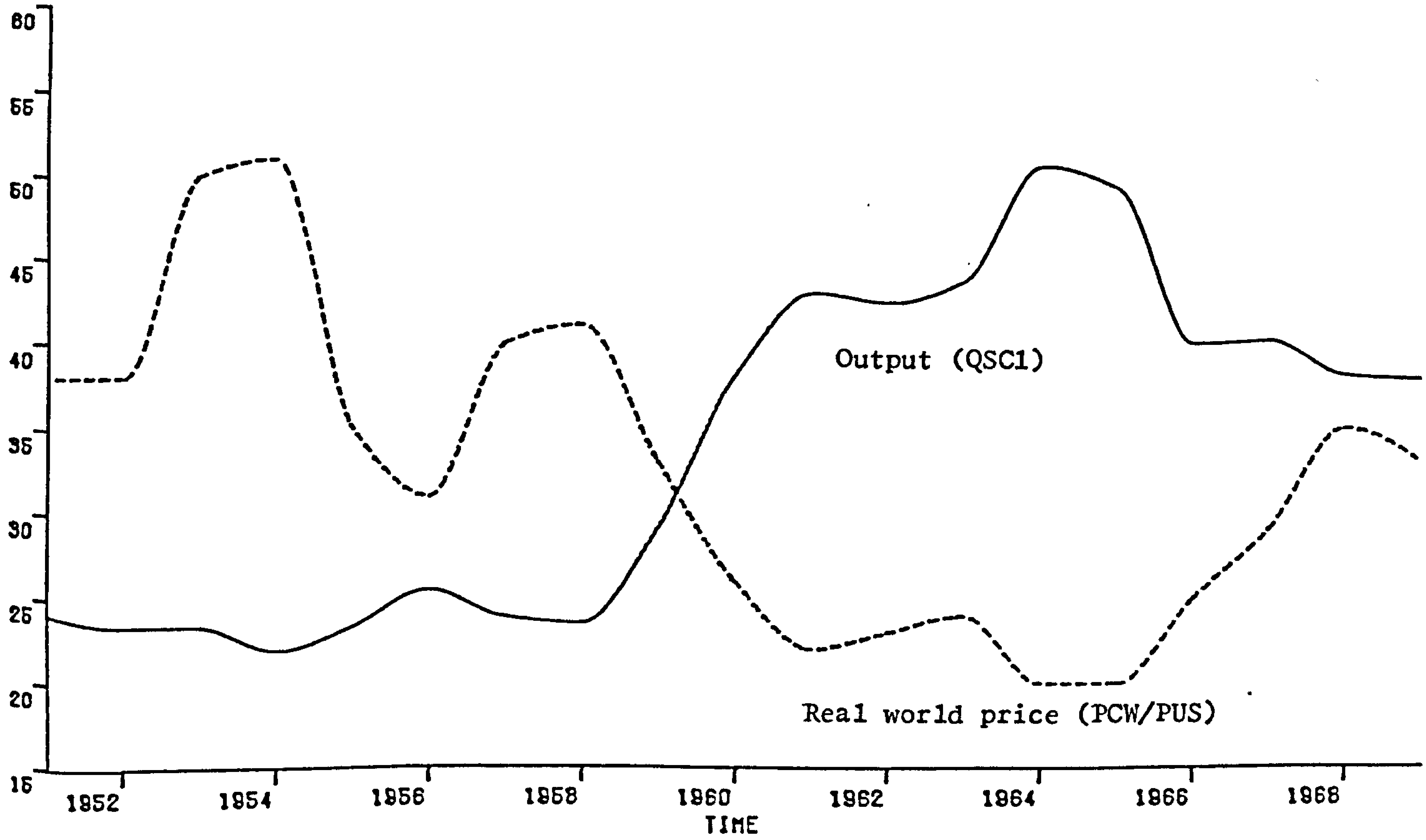
termination of a spraying subsidy in Ghana in 1966. Import volumes grew at about 2.3% in the 1950's and 3% in the 1960's. FIGURE 2.2 shows clearly how export value and unit value move in harmony, while volume and value move in opposite directions, due to the low price elasticity of demand.[5]

(2) Instability in the cocoa market

Some indication of the magnitude of instability in the cocoa market is provided by FIGURE 2.3. The real annual world price has fluctuated between a peak annual average of 51 cents per pound in 1954 and the low of 20 in 1964 and 1965[6].

Long-run (cyclical) price fluctuations are generated by a classic cobweb relationship of lagged output to price changes; planting lagging behind price changes by about five years. Intermediate (annual) price movements reflect yearly variations in output, consumption, and inventories. Climate and disease are crucial factors in explaining output variations. It is possible for farmers to alter current output through variations in inputs such as weeding and spraying in response to current prices or costs, but these influences are very limited and counter-productive in view of the high opportunity cost of neglecting trees. Demand tends to be more stable than output, inventories, or price, and depends primarily on cyclical income changes in the industrial world. Finally, there are short-run (month to month) fluctuations attributable to speculative behaviour[7].

In view of this apparent instability in the international cocoa market, it is somewhat surprising that Ghana does not figure very highly in the rankings of instability computed from the cross-section studies cited in Chapter 1. From TABLE 1.1, although export price and quantity have been quite unstable, in revenue terms Ghana



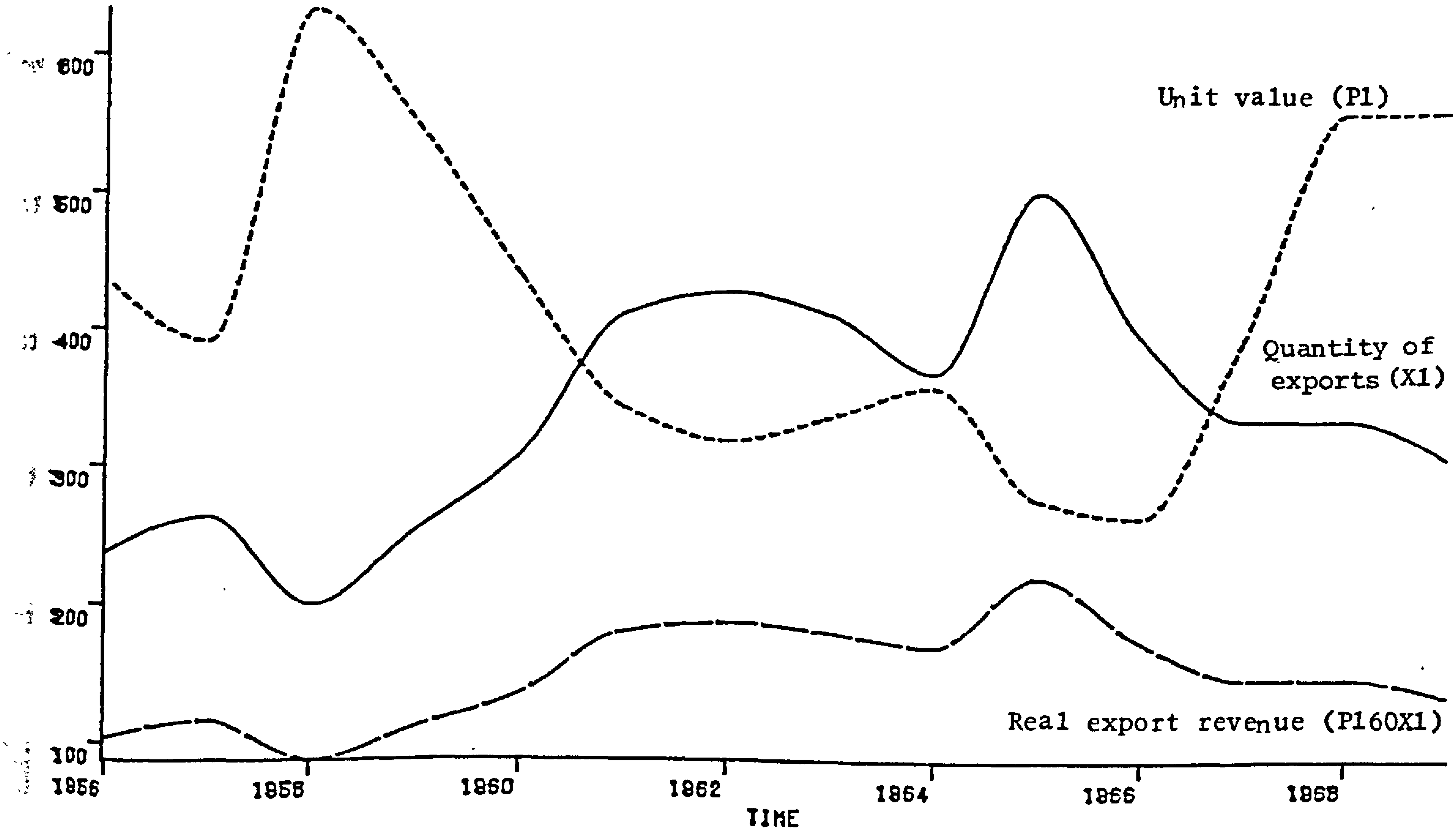
Source : APPENDIX IV.

FIGURE 2.3 Output and real world price for Ghanaian cocoa 1951-1969 ranks in the top half of the sample of developing countries in only 3 out of 13 studies. Moreover, Leith (1971) concluded that cocoa is the least unstable of Ghana's exports.

FIGURE 2.4 plots export price, quantity, and revenue for Ghana, and presents their associated instability indices in TABLE 2.4 [8]. It is notable that revenue is more unstable for the period 1956-1969 (15.5) than for Leith's period of 1957-1965 (12); and although export price and quantity movements offset each other somewhat in revenue terms, all three variables show considerable instability. This contrasts markedly with the conventional studies which focus on aggregate export values, which have been relatively stable (8.6). Services, however, introduced a destabilizing element (9.8).

It is also premature to conclude that export fluctuations do not have any serious consequences for Ghana until we have examined the way in which fluctuations are transmitted through the economy. This is particularly relevant in the Ghanaian case, since a marketing board system drives a wedge between the price received by the farmer and the price he would have received under a free market system.

FIGURE 2.5 plots some variables of interest to the farmer. Ghanaian output has been more unstable than world output, and stocks are particularly volatile. The Cocoa Marketing Board's policy of stabilizing farmer income by stabilizing producer price has met with limited success, as can be seen by comparing export revenue instability (15.5) and farmer income instability (12.9), and export price (19.1) with the real producer price (13.3). Both the real farmer price and income have been quite unstable.



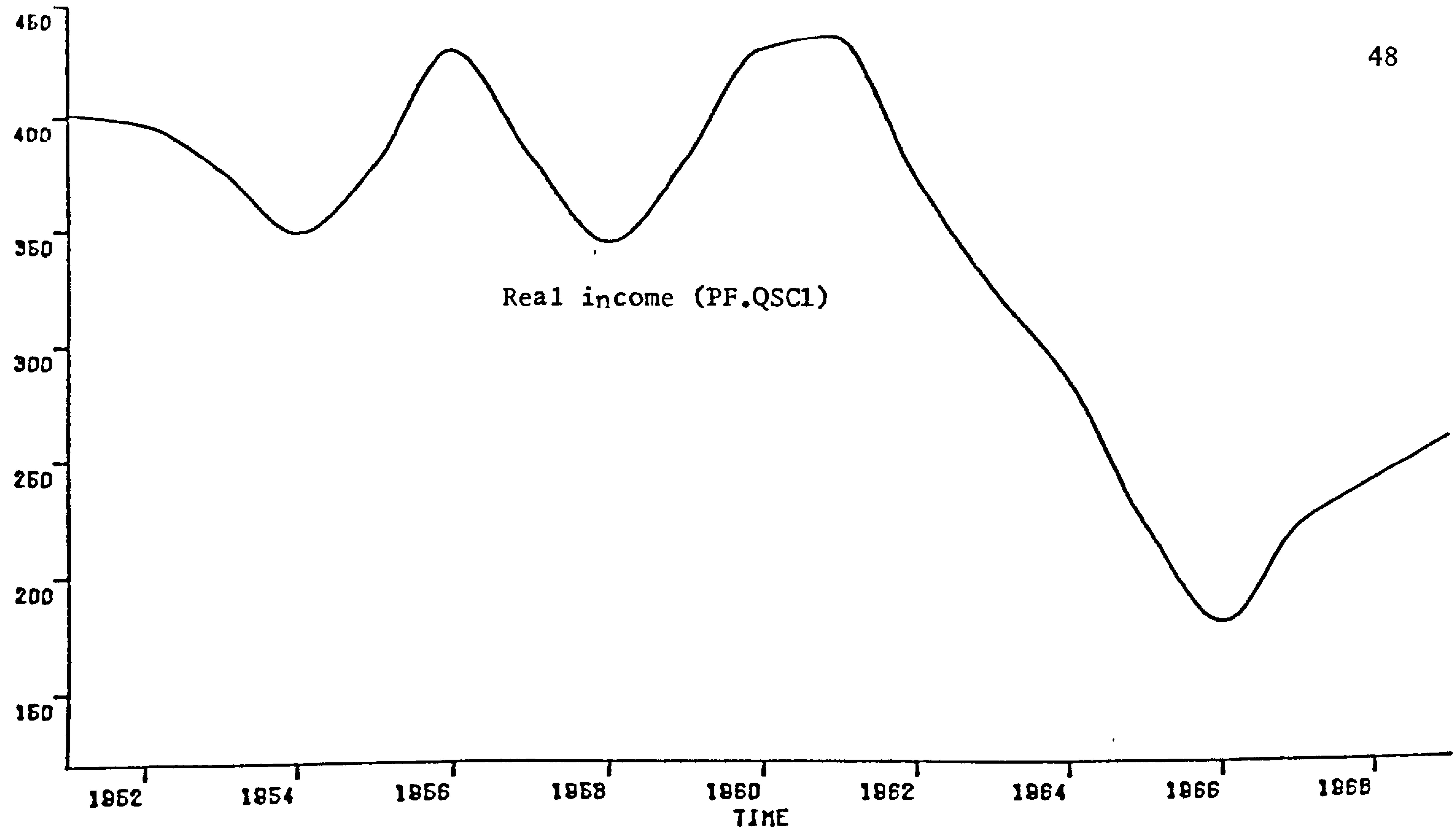
Source : APPENDIX IV.

FIGURE 2.4 Export price, quantity and real revenue for Ghanaian cocoa 1956-1969

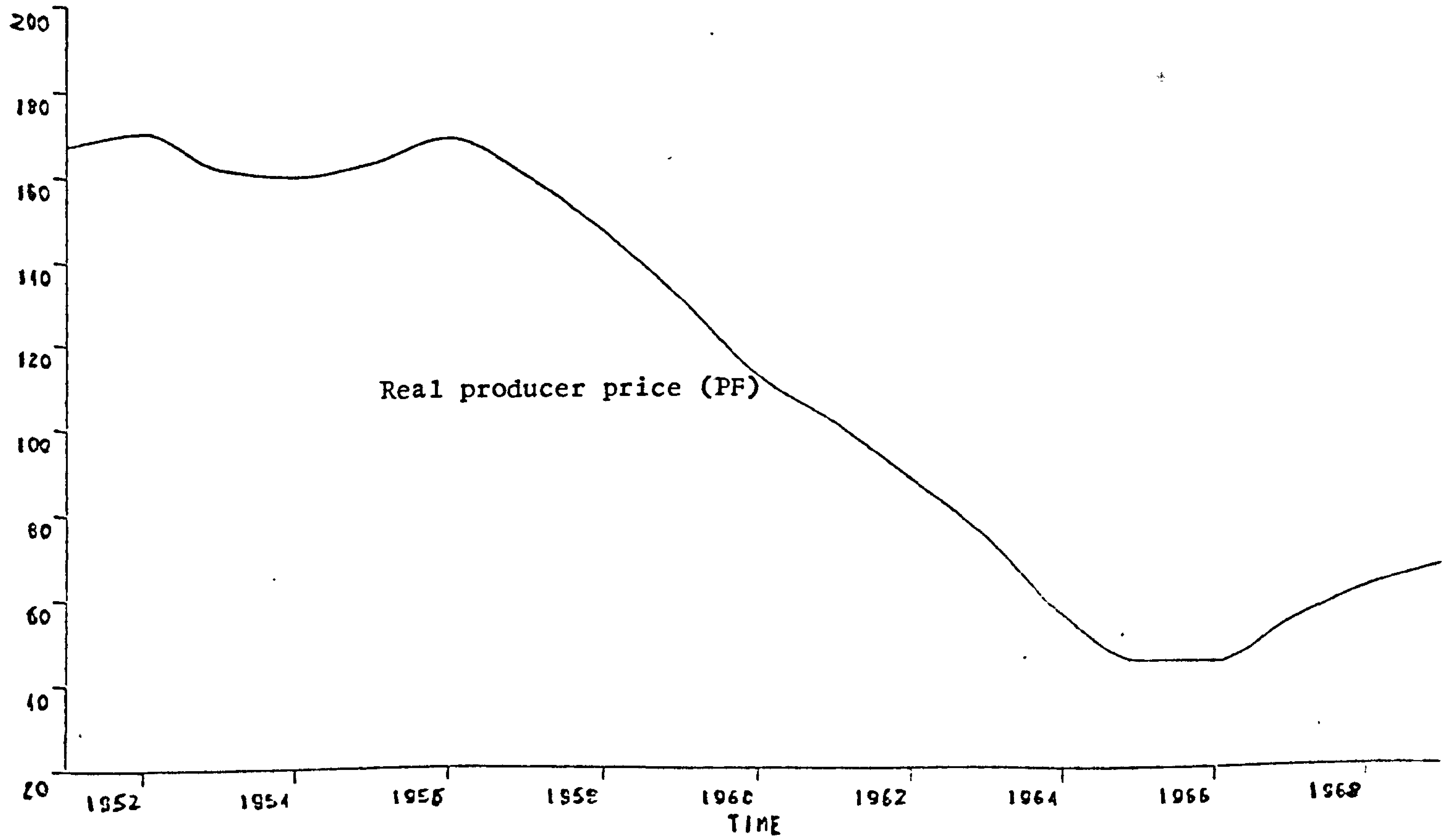
	I-I2 [1]
(1) Net exports of raw cocoa	15.1
(2) Unit value of cocoa exports	19.1
(3) Cocoa export revenue	15.5
(4) The value of merchandise exports	8.6
(5) Exports of goods and non-factor services	9.8
(6) Net world output of cocoa	5.6
(7) Calendar year grindings of cocoa	4.7
(8) Inventories of cocoa	15.4
(9) The real average annual spot price of New York Ghana Accra cocoa	13.5
(10) Output of cocoa in Ghana	8.8
(11) The real producer price of cocoa in Ghana	13.3
(12) The real income of Ghanaian cocoa farmers	12.9

1. See APPENDIX I. Source : APPENDIX IV.

TABLE 2.4 Some instability indices for Ghana 1956-1969



Source : APPENDIX IV.



Source : APPENDIX IV.

FIGURE 2.5 Real producer price per ton and income in Ghanaian cocoa farming 1951-1969

In order to ascertain the costs of instability we need to know how, and to what extent, the typical cocoa farmer can shift the burden of adjustment to fluctuations facing him on to other transactors, and how much of it he absorbs himself. There will be both short-run adjustment costs and longer-run effects on resource allocation. The effects on the government and the macro-economy in general will be discussed in Chapter 3.

Given the nature of cocoa production, there appears minimal substitution possibilities in the output or input mix in the short-run. Ghanaians do not consume cocoa in sufficient quantities for the substitution of domestic for export markets, and diversification into other products is not feasible in the short-run. Moreover, stocks of cocoa are held by operators abroad. On the input side, although farmers could cut costs by less intensive care of trees or the substitution of their own leisure time for paid employees, in practice all output tends to be harvested regardless of current prices and costs. The long-run opportunity cost of neglecting trees seems to outweigh the benefits of cutting marginal harvest costs in the short-run.

Evidence on the potential for adjusting wages or employment is mixed[9]. Minimum wages and labour shortages (particularly at specific points in the agricultural calendar such as harvest-time) constrain downward flexibility although there is a margin for adjustment in fringe benefits and where 'caretakers' are employed by owners to carry out maintenance and harvesting tasks for mature trees, since they tend to be paid by results. It is difficult to generalize here due to the highly seasonal nature of employment and the diversity of employment structures across regions (see TABLE 2.5); but about $^{2}/_{5}$ of the farms neither use permanent labour (usually

	Total man-days contributed :		
	(1) Farmers and relatives	(2) Annual labour and caretakers	(3) Total
	(%)	(%)	
May	33.1	66.9	71
June	24.7	75.3	154
July	21.4	78.6	167
August	31.3	68.7	70
September	33.3	66.7	36
October	-	100	18
November	-	100	25
December	-	100	18
January	16.7	83.3	5
February	13.3	56.7	2
March	100	-	9
April	46.5	53.5	39
Average	26.69	71.64	51.17

Source : Okali (1974).

TABLE 2.5 Estimates of labour input for farms of different sizes at Dominase in Brong-Ahafo share-crop) nor annual wage labour, but are family based with some contract/casual wage labour. It also seems unlikely that frictional unemployment reflected in short-run geographic or occupational mobility occurs, although such migration has been important in the long-run development of cocoa-farming, as has the trend movement of labour from the north to the south attracted by higher wages[10].

It seems likely, therefore, that much of the adjustment falls on farmer disposable income directly. Borrowing to cover a temporary loss is one option which does not seem to have been used very extensively historically (see Hill 1963); due partly to imperfect capital markets, and partly to farmers' aversion to banks or moneylenders in general. Moreover, there is some evidence of shortages of credit and high interest rates (Kotey, Okali et al. 1974). Consequently, one might expect an adjustment through import demand and consumption behaviour, with their respective income-multiplier effects. There is no evidence that farmers vary 'luxury' imports, although one might expect this to be more in evidence in the larger urban centres, where communications are better and perhaps the 'international demonstration effect' is stronger. The consumption multiplier effect depends upon whether the farmer responds in a 'Pavlovian' fashion to variations in his income, or treats such fluctuations as essentially 'transitory' and adopts a 'Permanent Income' or 'Life Cycle' view of the world. Unfortunately, there is no data on cocoa-farmer consumption in isolation and so we are unable to test whether differences in the magnitude of fluctuations in income in this sector lead to greater variations in consumption than for other groups in the economy. However, an aggregate consumption function is estimated and discussed in Chapter 3.

The longer-run impact of cocoa export fluctuations depends significantly on their effects on farmers' investment plans[11]. If fluctuations are anticipated, then farmers might adjust their capital stock of trees to the revised optimum stock in each time period. Then, given that in the case of cocoa, such adjustment is not instantaneous, costs will be attached to such Pavlovian movements. This is the essence of the notion that cobweb cycles impose costs because they issue 'perverse' market signals beyond the minimum necessary to achieve long-run allocative efficiency, and hence encourage over-reaction. Alternatively, farmers might be aware of the costs of adjustment involved, and prefer to maintain a fairly constant stream of output and respond to a longer-run signal representing a more 'permanent' change in market conditions. In this case, the cobweb is smoothed and the costs are identified as the idle resources at time t implicit in the alternate over and under utilization of capacity.

If, however, fluctuations are not anticipated by the farmer, then this introduces the possibility of behaviour under uncertainty. If, additionally, the farmer is risk-averse; then he may adjust in the long-run by substitution in the product mix towards lower yielding but lower risk crops, or move back into subsistence farming. This form of adjustment may be rational from the farmers' point of view but non-optimal from society's perspective; particularly if resources are diverted into socially less-productive forms. If the farmer is unable to adjust in response to his own risk-aversion, then he may be forced to bear the costs privately in terms of unstable income.

Available econometric evidence (reviewed below) suggests that Ghanaian cocoa farmers do not respond uncritically to annual variations in cocoa prices, but take a longer view of the price series. Consequently, given the inertia involved in cocoa supply, a damped cobweb is generated. The traditional explanation for this phenomenon is linked to Hill's (1963) historical analysis of Ghanaian cocoa farming. She paints the picture of a successful capitalist migrant farmer responding to price incentives, but with a long time horizon and little interest in 'get rich quick' tactics. Farmers were prepared to wait and see and plough back past profits. Some recent evidence on farmers in the Brong Ahafo region also supports this view, since they were prepared to take risks and continue planting regardless of fluctuations in current prices. Locals borrowed at high interest rates and migrants used previously accumulated reserves. See Okali (1974).

What has not been tested, is the alternative possibility that the damped cobweb results from risk-averse behaviour in response to the uncertainty generated by price or income fluctuations. The data above suggest that, on the face of it, farmers have some cause to be risk-averse; and cocoa receipts form a sufficiently large proportion of their total receipts to doubt the neutrality assumption that a change in price would leave the marginal utility of money constant. Moreover, investment costs are high and there are also feasible alternatives to cocoa available - coffee as another cash crop, and food for domestic sale or subsistence. The general rise in food prices and persistent shortages in the 1960's adds further incentives for diversification.[12] This is supported by evidence from Killick (1978) of the substitution of food and mixed production for cocoa and by

Rourke (1974). Rourke found that, although cocoa predominates in 1970 on 70% of cultivated land; other crops, notably plantain and cocoyams, are being intercropped without any apparent reduction in receipts.

The analysis thus far suggests that Ghana represents a classic case of a primary export-dependent economy, which is both commodity and geographically concentrated. The cocoa market is particularly susceptible to shifts in supply and inventory demand and price instability results from price and income inelasticity reflecting structural inertia in supply and stable consumption patterns in DCS. Yet, paradoxically, because of Ghana's monopoly power over cocoa prices and the existence of a marketing board mechanism, the potential consequences of export fluctuations are more complex than would appear at first sight. Instability is reflected not in aggregate export revenue but in farmers' income. In the short-run the possibilities for shifting the burden are limited, and it is likely that the major part of the adjustment is borne directly by the farmer himself. In the long-run one would like to test for the possibility of risk-averse behaviour, which is supported by some casual empirical evidence.

The remainder of this chapter will be concerned with the construction of a commodity model, incorporating the dynamic features of the cocoa market, and allowing for the possibility of risk-averse behaviour in the Ghanaian supply function.

(3) A commodity model for Ghana

There are many ways of modelling commodity markets depending on the structure of the market, the data base, and the objectives of the study. Following Weymar (1968), we can consider the following general model:

$$[1] \qquad QSC_t = f_1(P_t, P_{t-i}) + e_{1t}$$

$$[2] \qquad QDC_t = f_2(P_t, P_{t-i}) + e_{2t}$$

$$[3] \qquad P^*_t - P_t = f_3(SC_t) + e_{4t}$$

$$[4] \qquad SC_t \equiv QSC_t - QDC_t + SC_{t-1}$$

where:

QDC	=	Demand
QSC	=	Supply
P	=	Price
P*	=	Expected price
P_{t-i}	=	Lagged price
SC	=	Inventories
e	=	A classical error term

The first two equations are derived from standard microeconomic theory, omitting other relevant variables such as income for simplicity. Since inventories are determined by [4] then [3] is interpreted as a supply of storage function, and is used to explain the gap between current and expected price in terms of the current inventory level. The theory is that, if prices are expected to rise, more stocks will be carried i.e. more storage supplied. None of the equations explicitly defines the causal mechanism for price behaviour, but it is implicit within the assumptions about the lags involved and the simultaneity between the equations. Two cases are relevant here, given the known characteristics of the cocoa market. In the first case we might estimate:

$$[5] \quad QSC_t = f_1(P_{t-i}) + e_{1t}$$

$$[6] \quad QDC_t = f_2(P_{t-i}) + e_{2t}$$

$$[7] \quad P_t = P^*_t + f_3(SC_t) + e_{3t}$$

$$[8] \quad SC_t \equiv QSC_t - QDC_t + SC_{t-1}$$

Price is determined by the supply of storage function given data on P*, and a lag is included in [6] (e.g. the United Nations 1961).

However, in this present study where the data is annual, the effect on demand of a price change is likely to be within the year, while the supply response will be considerably longer[13]. Moreover, since inventories are apt to be quite volatile, we might expect some simultaneity between demand and inventories through their influence on price. Hence, the specific model chosen here was:

$$[9] \quad QSC1_t = f_1(PF_{t-i}) + e_{1t}$$

$$[10] \quad QDC_t = f_2(PW_t) + e_{2t}$$

$$[11] \quad PW_t = PW^*_t + f_3(SC_t) + e_{3t}$$

$$[12] \quad SC_t \equiv QSC_t - QDC_t + SC_{t-1}$$

$$[13] \quad QSC_t \equiv QSC1_t + QSC2_t$$

This is similar to [5] to [8] , except that current price is used in [10] and we distinguish between the world price (PW) affecting demand, and the Marketing Board price (PF) relevant to Ghanaian farmers. [13] is simply an identity specifying that world output is the sum of Ghanaian output and exogeneous output for the rest of the world. This is a demand for storage model in so far as price equilibrates between predetermined supply and two types of demand: consumption QDC_t and inventories for storage in the next period SC_t.

[10] and [11] also involve simultaneity in PW_t.

The general equilibrium bias of this model contrasts with previous studies which focus on one aspect of the cocoa market [14]. An example here is the United Nations (1961) commodity model in which the world price of cocoa was determined by an inventory to grinding ratio and forecasts of output and consumption. Weymar (1968) focused on the demand - price relationship and assumed supply exogenous, thereby neglecting the important cobweb features of the cocoa market. For a review of supply functions for cocoa, see Bateman (1969); and on the demand side, Behrman (1965).

We shall now proceed to examine in more detail the individual components of this general price model.

2.2 The Supply Function

(1) Supply functions for perennial crops

The traditional approach to supply functions for perennial crops assumes the farmer to be a rational profit-maximiser, and determines his supply response in terms of the price he anticipates for his crop, or his 'own' price relative to that of other crops. Then output is either estimated directly, or indirectly through a Nerlovian price-expectations framework and/or a partial-adjustment mechanism linking actual to cptimal output [15]. The focus on expected price perhaps reflects more the problems inherent in dealing with uncertainty, than neglect of the possible disturbing effects of uncertainty on farmer behaviour per se [16].

Recently, however, there have been attempts to break down this barrier. Batra (1975), for example, allowed for a random shift in the production function using the expected utility approach, and concluded that the risk-averse producer would lower output compared to the certainty case. Other relevant studies with similar results are Bardhan and Srinivasan's (1971) sharecropping model, and McKinnon's (1967) mean-variance analysis of the possible solution to output uncertainty through a system of optimal forward markets. An alternative insight has generated programming models in which the farmer is faced with a portfolio of alternative production plans, each with an associated mean and variance of returns, which he maximises subject to a utility function which includes assumptions about attitudes to risk. Profit-maximization enters as a special case where the utility function is linear. Support for nonlinearity of the utility function is based upon empirical studies of farmers' attitudes to risk. See Lin and Moore (1974) for a review.

No attempt will be made in this thesis to test a portfolio model, or to estimate utility functions for Ghanaian farmers. Rather, in (2) we construct a simple mean-variance model of cocoa production, to consider the possible implications of risk-averse behaviour by cocoa farmers. In (3) an empirical supply function is derived, and this is estimated in (4). The rationale is that, if risk-averse behaviour is important in explaining cocoa supply response, then the inclusion of risk variables in cocoa supply functions should improve the estimates and aid in the formulation of government policy.

(2) A theoretical model

Under certainty the farmer maximises the present value of the discounted future stream of net returns from investment in cocoa trees:

$$(1)\ \text{Max } \Pi_o = \int_0^\infty \Pi_t \, e^{-rt} \, dt$$

where:

r = The riskless rate of interest

Under uncertainty, the farmer maximises expected utility, or the present value of the expected utility of net returns:

$$(2)\ \text{Max } \Pi_o = \int_0^\infty E \left[U (\Pi_t) \right] dt$$

Assuming he produces only one crop (to eliminate interdependence in his decisions), and his utility function is quadratic, mean-variance analysis can be employed[17]:

$$(3)\ \text{Max } \Pi_o = \int_0^\infty \left[E(\Pi_t) - m \text{ Var } (\Pi_t) \right] dt$$

where:

m = The constant market price of risk

Or with a constant discount factor:

$$(4)\ \text{Max } \Pi_o = \int_0^\infty e^{-rt} \left[E (\Pi_t) - m \text{ Var } (\Pi_t) \right] dt$$

Assuming that total costs relate only to the cost of capital goods (i.e. no taxes or current assets and labour is always optimally adjusted), no depreciation, and competition ensures that factor prices are independent of farmer decisions (particularly investment decisions), then:

$$\Pi_t = P_t \, Q_t - q_t \cdot (I_t)$$

Where:

$$I_t \equiv \frac{dK}{dt} \equiv \dot{K}_t$$

P_t = The cocoa product price
Q_t = Cocoa output
q_t = The cost of capital goods
K_t = The real stock of cocoa-bearing trees

Substituting into (4) and dropping the time subscript for the profit components:

$$(5) \quad \text{Max } \Pi_o = \int_0^\infty e^{-rt} \left[E\left[P\,Q - q\,(\dot{K})\right] - m \text{ var}\left[P\,Q - q\,(\dot{K})\right]\right] dt$$

Let the production function be linear homogenous:

$$Q = \alpha K + \mu$$

and:

$$P = p + \varepsilon$$

Where μ and ε are random independent variables with the following distributions:

$$\varepsilon \sim N\,(O,\ \sigma_\varepsilon^2)\ ;\quad \mu \sim N(O,\ \sigma_\mu^2);$$

$$E\,(\varepsilon\,\mu) = O$$

and: $p, \alpha > O$

Substituting into the cash-flow relationship above, we have:

$$\Pi = \left[p + \varepsilon\right]\left[\alpha K + \mu\right] - q(\dot{K})$$

$$= p\alpha K + p\mu + \varepsilon\alpha K + \varepsilon\mu - q(\dot{K})$$

Expected profit becomes:

$$E(\Pi) = p\alpha K - q(\dot{K})$$

and the variance of profit is given by:

$$\mathrm{Var}(\Pi) = E(\Pi - E(\Pi))^2$$

$$= p^2 \sigma_\mu^2 + \sigma_\varepsilon^2 \alpha^2 K^2$$

Substituting these expressions back into (5) yields:

$$(6) \quad \mathrm{Max}\ \Pi_o = \int_0^\infty e^{-rt} \left[p\alpha K - q(\dot{K}) - m(p^2\sigma_\mu^2 + \sigma_\varepsilon^2 \alpha^2 K^2) \right] dt$$

In order to proceed, assumptions need to be made about the specific form of the cost function $q(\dot{K})$. To reflect rising input costs in the capital goods supplying sector as the farmer expands to meet anticipated demand, or rising opportunity costs in general, an Eisner-Strotz(1963) quadratic cost function was chosen[17]:

$$q(\dot{K}) = a\dot{K} + b\dot{K}^2 \; ; \quad a, b > 0, \quad q' > 0, \quad q'' > 0$$

Hence (6) becomes:

$$(7) \quad \mathrm{Max}\ \Pi_o = \int_0^\infty e^{-rt} \left[p\alpha K - a\dot{K} - b\dot{K}^2 - m(p^2\sigma_\mu^2 + \sigma_\varepsilon^2 \alpha^2 K^2) \right] dt$$

The problem then is to maximise:

(7')
$$\Pi_o = \int F(K_t, \dot{K}_t, t)\ dt$$

and can be solved through the use of classical calculus of variations by choosing K_t such that the optimal path of the capital stock satisfies at each time period the Euler differential equation[18]:

(8)
$$\frac{d}{dt} \frac{\partial F}{\partial \dot{K}} = \frac{\partial F}{\partial K}$$

with the second-order condition[19]:

$$\frac{\partial^2 F}{\partial \dot{K}^2} \leq 0$$

Following the Eisner and Strotz solution procedure provides an expression for the optimal capital stock (see APPENDIX II):

(10)
$$K_t^* = \left[K_o - \left[\frac{p\alpha - ra}{2m\alpha^2 \sigma\varepsilon^2}\right]\right] \cdot \exp \frac{\left[r - \left[r^2 + \frac{4m\alpha^2\sigma\varepsilon^2}{b}\right]^{1/2}\right]}{2} t + \frac{p\alpha - ra}{2m\alpha^2\sigma\varepsilon^2}$$

Hence, the exponential term approaches zero as time tends to infinity, ensuring that K^*_t approaches the stationary value given by the last term in (10). The exponential term is part of the homogeneous solution with the negative exponent. Eisner and Strotz (1963) suggest that the term with the positive exponent drops out because its coefficient is zero [20]. The expansion path is thus a constant minus a decaying exponential, which would justify the application of a Koyck distributed lag structure.

Compared to the original Eisner-Strotz formulation which included only a term representing the slope of the demand curve facing the firm in the denominator, there is a variance term in (10) representing price uncertainty.

Price uncertainty then has lowered the long-run optimal capital stock compared to the original Eisner-Strotz formulation. If there is uncertainty only in output ($\varepsilon \equiv 0$), the long-run optimal capital stock is independent of output uncertainty.

(3) An empirical model

There have been a number of attempts to model output response in cocoa, using the real producer price as the appropriate market signal, and usually employing a Nerlovian framework for expectations and partial-adjustment behaviour. For a critical review of this work, see Bateman (1969). The general impression is that these models perform quite well.

TABLE 2.6 confirms that short-run elasticities tend to be very low, although longer-run values are noticeably higher. There is, however, considerable variation. For example, between .15 for the Dominican Republic and 1.8 for the Cameroons.

We shall now construct an empirical supply function for Ghanaian cocoa, attempting to deal more fully than previous studies with short-run influences on planting and output, and with trend productivity effects. In addition, some allowance is made for the possible effects of uncertainty on the planting decision.

One might describe the general technical production function for cocoa as:

$$(11) \quad Q_t = F\ (K_t,\ W_t,\ \Theta_t)$$

where:

K_t = The stock of bean bearing trees

W_t = A variable relating to short-run influences on output such as annual rainfall

Θ_t = The pattern of yield of cocoa trees

Q_t = The output of cocoa

Assume initially that Q_t refers to potential output and depends only on the capital stock:

$$(12) \quad Q^*_t = f(K_t)$$

Sample	Period	Price elasticity (a) Harvest	(b) Short-run	(c) Long-run
Ghana	1930-1940		.43	
Ghana	1920-1939		.17	
"	1920-1946		.15	
Nigeria	1920-1945		1.29	
Ghana	1947-1964			.71
Nigeria	"			.45
Ivory Coast	"			.8
Cameroons	"	.68		1.81
Brazil	"	.53		.95
Ecuador	"	—		.28
Dominican Rep.	"	.03		.15
Venezuela	"	.12		.38
Average		.34		.69

Source : Bateman (1969).

(a) Response at harvest to current price.

(b) Response to lagged price .

(c) Response to lagged price including Nerlovian adjustment where significant.

TABLE 2.6 Some supply elasticities for cocoa

Since K_t depends on past plantings:

[13] $$K_t = \sum_{i=k}^{\infty} I_{t-i}$$

where:

I_t = Gross investment in cocoa, or the number of acres of trees planted in time t

k = The age at which trees first bear

Then potential output will depend on the yield of trees:

[14] $$Q^*_t = \sum_{i=k}^{\infty} Y\, I_{t-i}$$

where:

Y = The potential yield of trees per acre planted in t-i.

Assuming the relationship is linear and we eliminate an infinite amount of data:

[15] $$\Delta Q^*_t = \alpha_1\, I_{t-k}$$

Hence, changes in potential output depend upon past plantings.

Next, specify investment behaviour in terms of a partial-adjustment to optimum capital stock K^* (depending on the constraints facing the farmer), reflected in the average adjustment coefficient β:

[16] $$I_t = \beta(K^*_t - K_{t-1})$$

Let K^* in turn depend linearly on an, as yet, undefined variable $\hat{P}_t$, which refers to all those subjective factors pertaining to costs and returns influencing the investment decision:

[17] $$K^*_t = \beta_o + \beta_1\, \hat{P}_t$$

Substituting [17] into [16] produces:

[18] $$I_t = \beta\, \beta_o + \beta\, \beta_1\, \hat{P}_t - \beta\, K_{t-1}$$

Unfortunately, since there is no data on new plantings, one is unable to estimate [18] directly but must combine it with the output equation [15] :

$$[19] \qquad \Delta Q^*_t = \alpha_1 \beta \beta_o + \alpha_1 \beta \beta_1 \hat{P}_{t-k} - \alpha_1 \beta Q_{t-k-1}$$

where a lagged output variable is used as a proxy for the lagged capital stock variable in the absence of data.[21]

The next step is to specify the relationship between actual and potential output, in order to introduce the effects of climate and of current economic factors on harvested output. This recognises a deviation of current from potential output.

Let these short-run factors be represented by a variable W and potential output in [15] approximated by a linear yield function derived in APPENDIX III:

$$[20] \qquad Q_t = g_1\left(\sum_{i=k}^{f-1} I_{t-i}\right) + g_2\left(\sum_{i=f}^{\infty} I_{t-i}\right) + \delta W_t$$

Or, to eliminate an infinite amount of data:

$$[21] \qquad \Delta Q_t = g_1 I_{t-k} + (g_2 - g_1) I_{t-f} + \delta\Delta W_t$$

Combining the investment relationship of [18] with this modified version of the output relationship [15] yields the following first-order difference equation:

$$[22] \qquad \begin{aligned} \Delta Q_t = {} & g_2 \beta_o \beta + g_1 \beta \beta_1 \hat{P}_{t-k} + (g_2 - g_1) \beta \beta_1 \hat{P}_{t-f} \\ & - g_1 \beta Q_{t-k-1} - (g_2 - g_1) \beta Q_{t-f-1} + \delta\Delta W_t \end{aligned}$$

Before proceeding to specify $\hat{P}$ in more detail, there are three other factors which might be added to [22] . Firstly, a productivity variable (T_t) accounting for the introduction of new techniques over the period.[22] Secondly, subjective views about the attributes of other crops on the cocoa planting decision ($\hat{S}$). Finally, there is the impact of other disturbances, possibly socio-political, on output represented by a dummy variable (D).

Hence [22] is expanded to:

$$\Delta Q_t = g_2\ \beta_o\ \beta + g_1\ \beta\ \beta_1\ \hat{P}_{t-k} + (g_2 - g_1)\ \beta\ \beta_1\ \hat{P}_{t-f}$$

$$[23] \qquad - g_1\ \beta\ Q_{t-k-1} - (g_2 - g_1)\ \beta Q_{t-f-1}$$

$$+ \delta\ \Delta\ W_t + \rho\Delta\ T_t + D + g_1\ \beta\ \beta_2\ \hat{S}_{t-k}$$

$$+ (g_2 - g_1)\ \beta\ \beta_2\ \hat{S}_{t-f}$$

The model thus incorporates a cobweb dimension in so far as current output depends on past plantings, which in turn are related to past expectations about risks and returns. Fluctuations in output are also traceable to factors affecting the harvest in the shorter-run. Institutional/technical lags are captured by a partial-adjustment mechanism, specifying that farmers adjust only to the extent of a fraction of the difference between the acreage they would like to plant and that actually planted in the previous period.

We need at this juncture to specify more precisely the relationship between planting and the farmer's attitude to risk and return subsumed under the $\hat{P}$ variable above. The first problem is to decide what variables might be relevant to the investment decision. Previous studies have invariably focused on the own price of cocoa and, possibly, a relative price of a substitute in production. We shall, however, test for the influence of both real price and real income received by the farmer. Substitute crops are also included, but unfortunately no reliable series could be found for the return to food production - a possible substitute for cocoa production, especially in view of the inflation of food prices in the 1960's reflecting import controls and domestic supply bottlenecks. The deflation of the price and income variables by a consumer price index does, however, allow partially for this influence. It has generally been assumed that neither costs (of land, labour, seed etc.)nor yields influence the planting decision directly, since yields tend to change slowly and other costs are considered to vary with price[23]. For Ghana we could find no data on yields, but we did try a variable pertaining to planting costs. Theoretically one would also want to take account of the costs of borrowing and a time discount factor, but the data is not forthcoming. We were wary of using an aggregate proxy such as the return on government securities in view of the relative backwardness of the monetary sector in Ghana, and the stylized facts about the institutional/sociological context of cocoa investment in the past[24].

A second problem refers to the way in which we model the adjustment behaviour of cocoa farmers, since this defines the costs we attach to instability. We want to know how they respond to fluctuations in $\hat{P}$ in terms of their investment in cocoa. It seems unlikely that the process is a costless and instantaneous adjustment at each time-period. Consequently, the movement from actual to optimum capital stock is dealt with by including a partial-adjustment mechanism and an appropriate distributed lag formation. However, this takes no explicit account of behaviour under uncertainty, because it does not separate out the inertia attributed to technical and institutional factors and that attributable to risk-aversion. In this sense, the adjustment coefficient β represents a catch-all. The problem, then, is to develop a forecasting equation to relate K^* to $\hat{P}$ and thus to separate out the uncertainty element from the partial-adjustment process in general.

Assuming the farmer does indeed maximise expected utility and has a subjective probability distribution around $\hat{P}$; the need is to attempt to approximate the expected value signal which causes him to revise his planting, and the cost of risk. The mean-variance approach confines the analysis to the first and second moments of the probability distribution, with the mean representing expected return and the variance representing the cost of risk. A priori, there is no reason to believe that the farmer's attitude to risk is moulded solely by the second moment, but this is assumed here to keep the estimation procedure manageable. This still, however, leaves the issue very open since, the absence of information on the time interval of fluctuations which influence decisions, leaves the analysis compatible with a whole range of forecasting models. If one knew, a priori, the amplitude and frequency of those fluctuations relevant to the farmer's plans, we could isolate them from the given time-series. It seems unlikely that farmers respond to short-run speculative movements generated within the year, so the focus here is on intermediate annual fluctuations and cobweb movements generated in the cocoa market. This still leaves considerable room for experimentation with models which vary in the weights they attach to high and low frequency variations.

The simplest forecasting model is to assume risk to be independent of expected values. Behrman (1968b) for example, specified risk as a three-year moving average standard deviation but ignored the relationship between this variable and the generation of expected values based on an autoregressive process. Other examples of risk measures which do not include any explicit correction for trend, and might be included in a model which allowed for both expected return and risk, are I-I1 and I-I2 in APPENDIX I.

The most popular method of introducing expectations into agricultural supply models is through a Nerlovian autoregressive scheme. For example, we might specify:

[24] $$\hat{P}_t = \hat{P}_{t-1} + \lambda(P_t - \hat{P}_{t-1})$$

which specifies that expected returns depend only partially on current or past returns, as each year farmers revise their expectations in proportion to the error made in predicting returns this year. Some farmers may have faith in their original prediction even if it turns out to be incorrect, while others revise down their expectations. The expectations of the group are reflected in the expectations coefficient λ and a Koyck distributed lag structure embodying geometrically-declining weights ensures that more recent prices exert a stronger influence on planting[25].

Although this method recognises the role of error in decision-making and relates behaviour to a learning or adaptive expectation process it focuses on expected values and does not explicitly introduce uncertainty or attitudes to risk. Trail (1978), however, has recently shown that, in principle, there is no reason why risk should not be incorporated in the model by defining a risk variable, giving it a distributed-lag structure similar to $\hat{P}_t$, and then defining the relationship between the two variables. In this thesis, adaptive expectations were not assumed since their inclusion together with the partial-adjustment process in [23] results in considerable intractability in estimation and the impossibility, in general, of separating out estimates of β and λ[26]. Moreover, autocorrelation is formally introduced into the model; and finally, it would not be possible to derive the internally-generated risk variable in line with Trail from the expected value variable. One could introduce a risk variable generated outside the model, but it is difficult to justify an autoregressive theory for expectations but attitudes to risk obtained as deviations from an <u>alternative</u> expected value series.

Consequently, we assumed that risk was externally-generated but derived the risk variable from the expected return series <u>prior</u> to estimation of the supply function. Hence, [17] becomes:

[17'] $$K^*_t = \beta_o + \beta_1\bar{P}_t + \beta_3 R_t$$

and $$R_t = (P_t - \bar{P}_t)^2$$

where:

$\bar{P}_t$ = Expected return

R_t = Risk

Then our basic supply function becomes:

[22'] $$\Delta Q_t = g_2\, \beta_o\, \beta + g_1\, \beta\, \beta_1\, \bar{P}_{t-k} + (g_2 - g_1)\, \beta\, \beta_1\, \bar{P}_{t-f} + g_1\, \beta\, \beta_3\, R_{t-k} + (g_2 - g_1)\, \beta\, \beta_3\, R_{t-f} - g_1\, \beta\, Q_{t-k-1} - (g_2 - g_1)\, \beta\, Q_{t-f-1} + \delta\Delta W_t$$

(4) Results.

In view of the size of equation [22'], and the number of possible permutations for the R and P variables, the estimation procedure was carried out in a number of steps. To begin with, we tried a simplified price model using ordinary least squares regression (OLS). To narrow down the range of prices representative of the yield function, various combinations of lagged producer prices for cocoa were tested together with their appropriate lagged output variables. The best result was a single lag of eight periods - midway between the two a priori limits of minus five and minus twelve. No income variable was significant. The next step was to try out a number of substitute crops. Price and income series were added for coffee, rice, palm oil and palm kernels, but none proved significant. Neither did the deflation of the cocoa series by these variables and a weighted index combining them, prove significant. The introduction of a time trend representing trend productivity improved the fit, but dummies for discontinuities in output (for example in 1964) contributed little to the model.

At this stage we considered the influence of short-run variables on harvested output. We could, however, find no significant results for changes in real current producer prices and incomes, or in real planting costs [27]. A number of trials with different rainfall variables also proved inconclusive.

In order to test for the importance of fluctuations in prices and incomes as indicative of the risks inherent in cocoa farming, we constructed OLS trends for real price and income and derived their associated residuals. The variance and standard deviation were computed and included in the basic model. Some transformations were also carried out on the residuals - first differences and first differences weighted by the fitted values for the slope and intercept of the regression. Non-trend corrected measures were also tried (see APPENDIX I). In a second series of runs, the actual values for price and income were replaced by the fitted values from the regressions to embody a mean as well as a variance dimension. Finally, we repeated the analysis using trend estimates from a moving-average model with variations in both the weights and length of the moving average.

Despite these efforts we were unable to improve upon the simplified cobweb model in which changes in output were related to past plantings of cocoa trees, themselves dependent on producer prices lagged eight periods, and a trend increase in productivity:

[23] $$\Delta QSC1_t = a_{11} + a_{12}PF_{t-8} + a_{13}QSC1_{t-9} + a_{14}TIME + e_{1t}$$

where:

$QSC1$ = Gross output of cocoa beans in Ghana

PF = The real producer price of cocoa

$TIME$ = A time trend

$a_{11} = g_1 \beta_o \beta$

$a_{12} = g_1 \beta \beta_1$

$a_{13} = g_1 \beta$

e_1 = A classical error term

The estimates are presented in APPENDIX VI together with some relevant statistics, and the data is defined in APPENDIX IV.

There are perhaps three qualifications to be made before concluding from these results that there is no significant relationship between aggregate cocoa output and fluctuations in producer prices and incomes. Firstly, the level of aggregation may conceal relationships at the regional level in Ghana. Secondly, although we have tried a number of forms of the risk and return variables, there is considerable room for further experimentation. Finally, it may be that the 'roundabout' derivation of the final estimating equation results in loss of information embedded in the 'scrambled' coefficients. Unfortunately, if we want to explain cocoa output in a more sophisticated way than would be implied from a simple forecasting model, then the absence of data on investment precludes the separation of the planting decision from the determination of output.

A second implication from the study here is that there is no evidence that farmers are guided in their investment decision by variations in their income rather than in the real producer price.

Finally, we were unable to show any significant relationship between short-run factors such as rainfall or producer costs, and output. Once again, the separation of the output and investment equations might modify this conclusion.

In view of the relatively poor goodness of fit for the supply equation, an alternative forecasting equation was substituted when the model was simulated. Absolute output was made a function of the real producer price lagged five and eight periods and a time trend. This was done in order to examine the impact of output fluctuations independently of the relatively sophisticated theory of farmer behaviour discussed in this chapter. The supply elasticities with respect to the price variables were calculated to be .575 and 1.02.

2.3 The Demand Function

Consider the following general form for an aggregate[28] demand function for cocoa:

[24] $$QDC_t = f(\alpha_o + \alpha_1 PW_t + \alpha_2 PW_{t-i} + \alpha_3 PS_t + \alpha_4 PS_{t-i} + \alpha_5 S_t)$$

where:

QDC = The average annual grinding of cocoa beans

PW = The average spot price of cocoa

PS = The average spot price of a substitute or complement in consumption

S = The expected average sales of final cocoa products

α_o = A constant

$\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5$ = Regression coefficients

In the absence of data on final cocoa consumption, a derived function for users of cocoa products is estimated, using grindings of cocoa beans for use in the manufacture of final products[29].

In addition, since the expected average sales of final cocoa products is not known, S is approximated by the real income of consuming countries lagged one period.

Empirical studies of the demand function for cocoa have tended to follow this basic format, with the possible addition of a time trend to capture secular movements in tastes. Own price elasticities tend to be low (see TABLE 2.7), and income elasticities less than unity. The cross-elasticity with respect to sugar tends to be insignificant, due to the fact that it acts as both a complement in chocolate manufacture and a substitute for all confectionary products. Soybean is taken as a proxy for vegetable oil, which acts as both a substitute for cocoa butter and complement to cocoa powder. On balance, the substitute effect has tended to predominate.

Various forms of [24] were estimated, including a time trend 'taste' variable and sugar and soybean variables. The price and income variables were all in real terms. The income variable was computed as a weighted average of the national incomes of the major OECD consuming countries deflated by a United States wholesale price index and adjusted for population changes. The weights represent average shares in consumption over the period 1951 to 1975. See TABLE 2.8. The most satisfactory result was found to be the following:

$$[25] \qquad QDC_t = a_{31} + a_{32}\left(\frac{PCW}{PUS}\right)_t + a_{33}\ YOECD_{t-1} + e_{3t}$$

The results are tabulated in APPENDIX VI and conform to a priori expectations. A time trend was insignificant when an income variable was present and suggests that the influence of tastes might be satisfactorily subsumed under the income variable. The sugar variable was insignificant in all cases, despite some experimentation

Sample	Period	Elasticity[1] (a) Cocoa	(b) Sugar	Soybean	Income	Source	
U.S.A.	Unspecified	-.35				The United Nations (1961)	
Belgium		-.27					
Austria		-.35					
Denmark		-.49					
W. Germany		-.49					
Sweden		-.35					
Average[2]		-.38					
Canada	1947/8-1963/4	-.19	-.12	.43	.72	Behrman (1968a)[3]	1. Short-run only based on regression means.
France		-.38	-.15	.05	.68		
W. Germany		-.18		.32	.93		2. Unweighted.
Italy		-.21		.05	.93		
Netherlands		-.89		.77	.62		3. In an earlier study he found insignificant results for (a) and (b) for France, W. Germany, U.K. and the Netherlands for the period 1950-1961.
Spain		-.24		-	.85		
U.K.		-.16		.14	.71		
U.S.A.		-.25	-.08	.19	-		
Rest of world		-.25	-.2	-.74	-		
Average[2]		-.31			.78		
Aggregate	1953-1965[4]	-.25				Weymar (1968)	4. Quarterly.

TABLE 2.7 Demand elasticities for cocoa.

	(1) Average consumption metric tons (000)	(2) Share in world average (%)
U.S.A.	249.88	22.0
W. Germany	116.52	10.3
U.K.	95.96	8.5
Netherlands	93.52	8.2
France	51.44	4.5
Spain	24.92	2.2
Italy	24.6	2.2
World average	1133.68	
Total average share of major consumers (%)	57.9	

Source : Gill and Duffus (1972).

TABLE 2.8 Average consumption of cocoa grindings by major consuming countries 1951-1975.

with alternative series. The 'own' price elasticity was calculated to be -.136 and the lagged income elasticity .597. These conform to past studies, although both responses are weaker. This may reflect the passage of time.

2.4 The Inventory Function

The most popular explanation of inventory behaviour in a market where the spot price of a commodity is generated by the operation of a futures market, is based upon the supply of storage model. See Weymar (1968). Weymar derives an equation for the monthly movement in the spot price of New York Accra cocoa explained by the long-run equilibrium price, the current inventory to grinding ratio, and the expected long-run inventory to grinding ratio [30]. Since we are concerned here with annual movements, a simpler model was adopted in which real annual spot prices were related to a constant and the current inventory to grinding ratio:

$$[26] \qquad PW_t = \alpha_o + \alpha_1 \left(\frac{SC}{QDC}\right)_t$$

SC_t represents the amount that needs storage at the end of the year and incorporates a relationship between the available stocks and the level of demand i.e. the larger the ratio of stocks needing storage to demand, the lower the price.

The drawback with [26] is that it neglects the cost side of stock behaviour and speculation. It was decided, therefore, to specify an additional function which attempts to include expectations, albeit still in a crude fashion. The inventory to grinding ratio was made dependent on price expectations on the basis of simple adaptive error-learning behaviour:

[27] $$\left(\frac{SC}{QDC}\right)_t = \alpha_o + \alpha_1 \hat{PW}_t ; \quad 0 < \lambda \leqslant 1$$

where:

[28] $$\hat{PW}_t - \hat{PW}_{t-1} = \lambda(PW_t - \hat{PW}_{t-1})$$

λ thus represents the expectation adjustment coefficient. Substituting [28] into [27] , solving via a Koyck transformation, and transforming it into an expression for changes in the stocks to grinding ratio yields:

[29] $$\Delta\left(\frac{SC}{QDC}\right)_t = \alpha_o\lambda + \alpha_1\lambda\ PW_t - \lambda\left(\frac{SC}{QDC}\right)_{t-1}$$

Both [26] and [29] were estimated with the price variable in real terms. The estimating equations are as follows:

[30] $$\left(\frac{PCW}{PUS}\right)_t = a_{41} + a_{42}\left(\frac{SC}{QDC}\right)_t + e_{4t}$$

[31] $$\Delta\left(\frac{SC}{QDC}\right)_t = a_{51} + a_{52}\left(\frac{PCW}{PUS}\right)_t + a_{53}\left(\frac{SC}{QDC}\right)_{t-1} + e_{5t}$$

The variables are defined in APPENDIX IV, and the results presented in APPENDIX VI.

2.5 Cocoa Exports

To complete the cocoa subsector and provide the link to the macro-model constructed in Chapter 3, cocoa export price and quantity need to be considered.

The price Ghana receives for her exports is not equal to the world price of cocoa, since the latter is proxied by the New York price, and Ghana sells less than a quarter of her output to the USA. Consequently the export price of cocoa in cedis was estimated as a function of the world price. The addition of a lag reflects the fact that much of the cocoa is sold forward to oligopolistic firms.

[32] $$Pl_t = a_{61}\,(PCW/PUS.PUS/100)_{t-1} + e_{6t}$$

Since a negligible quantity of cocoa is consumed domestically but there is some smuggling, the quantity of cocoa exports was regressed on cocoa output and a dummy for 1964 to allow for an exceptional harvest:

[33] $$Xl_t = a_{71}\,QSCl_t + a_{72}\,D64 + e_{7t}$$

2.6 Summary

We are now in a position to assemble the equations of the cocoa subsector derived in 2.2 to 2.5, including the additional supply function for use in simulation.

[23] $$\Delta QSCl_t = a_{11} + a_{12}\,PF_{t-8} + a_{13}\,QSCl_{t-9} + a_{14}\,TIME + e_{1t}$$

[37] $$QSCl_t = a_{21} + a_{22}\,PF_{t-5} + a_{23}\,PF_{t-8} + a_{24}\,TIME + e_{2t}$$

[25] $$QDC_t = a_{31} + a_{32}\left(\frac{PCW}{PUS}\right)_t + a_{33}\,YOECD_{t-1} + e_{3t}$$

[30] $$\left(\frac{PCW}{PUS}\right)_t = a_{41} + a_{42}\left(\frac{SC}{QDC}\right)_t + e_{4t}$$

[31] $$\Delta\left(\frac{SC}{QDC}\right)_t = a_{51} + a_{52}\left(\frac{PCW}{PUS}\right)_t + a_{53}\left(\frac{SC}{QDC}\right)_{t-1} + e_{5t}$$

[32] $$Pl_t = a_{61}\,(PCW/PUS.PUS/100)_{t-1} + e_{6t}$$

[33] $$Xl_t = a_{71}\,QSCl_t + a_{72}\,D64 + e_{7t}$$

To complete the model requires some identities. One defines world cocoa output as the sum of Ghanaian and rest of the world output. Another relates current inventories at the end of the period to supply and demand in the current period and stocks held at the beginning of the period. Finally, the real value of cocoa exports was obtained from their current value deflated by the implicit price index at 1960 prices. This variable forms the major link between the cocoa sector and macro-economy.

[34] $$QSC_t \equiv QSC1_t + QSC2_t$$

[35] $$SC_t \equiv QSC_t - QDC_t + SC_{t-1}$$

[36] $$P16OX1_t \equiv (P1_t \cdot X1_t) / P_t \cdot 100$$

The results are presented in APPENDIX VI and APPENDIX VII based upon alternative estimation methods. The justification for these estimation methods and the interpretation of the results is deferred until 3.3.

Notes

1. The average tree begins to bear on a commercial scale after about five years and attains its maximum yield after ten to fifteen years. It continues to bear until it reaches fifty to sixty years old. A crop year runs from October of one year to September of the next. For more details on this angle, see Kotey, Okali et al. (1974).

2. For an account of the origin and development of the cocoa industry in Ghana from 1894 to 1930, see Hill (1963).

3. Hershey in the United States, British Chocolate in the United Kingdom, and Nestle in Europe.

4. For the dynamics of the world cocoa market up to 1966, see Weymar (1968). Kumar (1974) also provides a useful summary of its institutional arrangements.

5. These figures are derived from Singh, De Vries et al. (1977).

6. The New York spot price of Ghanaian cocoa beans is usually taken as representative of the world price. This is justified in so far as all cocoa prices tend to move together; Ghana produces about a third of total output; and the United States consumes about a quarter of total output. The deflator is based upon a United States wholesale price index.

7. See Weymar (1968) and Kumar (1974).

8. Since none of the variables exhibited any significant trends on the basis of ordinary least squares regressions, and we are only interested in broad differences in magnitude, a simple instability index was used based on the average percentage changes in the variables. See APPENDIX I.

9. See Rourke (1974).

10. See Okali (1974).

11. We are not concerned here with the effects on consumers and manufacturers, but there might be trend demand feedback effects from the substitution in consumption and manufacturing of stabler synthetics.

12. This is in addition to the disincentive to plant cocoa resulting from the fall in the real cocoa price from 1955 to 1966. See FIGURE 2.5.

13. [5] to [8] are more relevant to a monthly model where a demand lag would be about six months duration, and a supply lag at least five years.

14. An exception here is Behrman (1968a) but his complete system was not published.

15. For a Cobb-Douglas production function, see Lin and Moore (1974). A survey of Nerlovian supply functions for agriculture can be found in Bateman (1969).

16. For example, Schultz (1964).

17. For more details on the derivation of this equation in the context of the theory of the firm, see Stephens (1974). He also discusses the Eisner-Strotz and Jorgenson models using the uncertainty framework adopted here.

18. See Intriligator (1971).

19. For the conditions for a maximum of $(7')$ in the certainty case, see Eisner and Strotz (1963).

20. They argue that subject-matter considerations do not suggest that the capital stock approaches infinity as time tends to infinity i.e. the terminal value of the capital stock is not infinite.

21. The use of the lagged output variable as a proxy for the lagged capital stock is not very satisfactory but was adopted here in order to retain the spirit of the partial adjustment mechanism.

22. The productivity variable was included to capture the impact of the introduction of new techniques, higher yielding varieties and pest control, not reflected in the yield coefficients. There was no equivalent to the 'Green Revolution' in Ghana but a more piecemeal application of government policies, primarily to eliminate swollen-shoot disease (by cutting down infected trees) and reduce the insect-transmitted capsid disease by the spraying of insecticide. There is evidence from Bateman (1970) that the effects may have been quite long-run, hence a trend and not a dummy variable; and that they were additive and not multiplicative.

23. See Behrman (1968b).

24. See Hill (1963).

25. For an explanation of the econometric properties of these models, see Johnston (1972).

26. See Johnston (1972,302). It is possible to obtain a solution with appropriate modifications, but none appeared plausible in the present context. For a discussion of this, see Behrman (1968b).

27. The data for these variables was taken from Bateman (1970).

28. Aggregation is justified in so far as consumption is concentrated in developed countries; the oligopolistic nature of the chocolate market ensures stable market shares; and manufacturers' reactions to changes in price tend to be interdependent and parallel.

29. Usually adjusted for net imports of cocoa products.

30. An alternative, and simpler model, was presented by the United Nations (1961). Although, essentially a forecasting model based on a casual empirical observation of the international cocoa market, it bears an uncanny resemblance to the supply of storage model. See Weymar (1968).

CHAPTER 3 : THE MACROECONOMY

3.1 A Macroeconomic Model for Ghana

In this chapter a short-run macroeconomic model for Ghana is constructed and estimated for the period 1956 to 1969, specifically to examine a number of hypotheses about the transmission of fluctuations between the export and domestic sector.

Section 3.1 briefly raises some of the general problems encountered when building models for developing countries, describes the format and 'bias' of the model, and indicates some of the particular problems which arise in the Ghanaian context. In sections 3.2 to 3.6 the model is derived and the implications for the TM assessed. In 3.7 we discuss the methods and problems of estimating the model and the interpretation of the results. The estimated equations are listed in APPENDIX VI and APPENDIX VII together with some appropriate summary statistics for their evaluation. The variables used in the model are defined in APPENDIX IV accompanied by their sources. Problems arising from the data are reserved for APPENDIX X.

(1) Model-building for developing countries

Although there has now been substantial work on model-building for DCS, pioneered by Klein (1950) in the late 1940's; models of LDCS have been almost exclusively confined to planning models for growth and development over the medium and long-run, to the neglect of cyclical problems. For a review of work in this area, see Ball (1973) and Blitzer (1975). This may partly be explained by the lack of adequate aggregate data, yet short-run models are important if only to enable policy-makers to correct any deviations from long-run growth paths through the appropriate choice of short-run policy tools.

Even given the will and data to construct such models, it is not always clear how appropriate it is to 'transfer' models designed for DCS. See Klein (1968). In particular, two modifications appear to be generally relevant. Firstly, allowance for 'structural' problems emphasising supply bottlenecks rather than deficient demand. For example, shortages of skilled labour or of imported machinery. Secondly, there is the need to recognise the relative backwardness of the monetary sector reflected, for instance, in the absence of an adequately developed interest-rate structure or credit supply. Both of these modifications are applicable to Ghana over the period we are concerned with.

(2) A model for Ghana

The model developed below contains 33 behavioural equations and 25 identities, and is disaggregated into five sectors to accompany the cocoa subsector derived in Chapter 2. These sectors deal separately with aggregate demand, aggregate supply, the government, money, and prices.

The model is derived principally along Keynesian lines in so far as the emphasis is placed upon the role of aggregate demand, but unemployment and excess capacity are captured through a partial-adjustment mechanism linked to a demand for labour function. The supply side is also represented through the linkages between the cocoa subsector and the rest of the economy. Fluctuations in cocoa supply, demand, and inventories, are directly related to aggregate demand through the multiplier repercussions of cocoa export revenue; and also indirectly through their impact on the budget position and foreign exchange market. Importance is also given to the effect of foreign exchange supplies on imports used both in final consumption and as inputs into the production function. The relative backwardness of the monetary sector is reflected in the choice of a modified quantity theory.

The construction of the model was inevitably constrained by the availability of consistent data series. We rely heavily on a set of social accounts compiled by Merritt-Brown (1972) for the period 1956 to 1969. Although the quality and range of the series is good by the standards of the developing countries, there were naturally some deficiencies which we discuss in more depth in APPENDIX X below. Despite the limited degrees of freedom available, we feel that the variables exhibit sufficient variance to enable the structure of the model to be estimated, whilst the time-period is not long enough to have expected significant long-run structural changes. The most serious problem, perhaps, is the number of sharp changes in policy over the period. For example, devaluation in 1967 and the coup in 1966. These 'shocks' change the structure of the economy, but given the small sample, make it difficult to test whether they have seriously affected the structure. Some attempt to cope with these factors through the use of dummy variables is made in the formulation of the equations.

The choice of appropriate level of aggregation for a model depends on the scope of the analysis and the resources available.

We intended originally to extend a model of Ghana published by Abbey and Scott Clark (1974), as a way of reducing construction costs and facilitating disaggregation in areas of particular relevance to this thesis. Unfortunately, we were unable to obtain their secondary data and so were obliged to reconstruct the model completely from primary sources. Comparison between the model here and the earlier one is considerably diminished by the numerous mistakes and ambiguities present in the earlier work, many of which may be put down to the poor standard of typographical presentation. In addition, since our emphasis here is upon the interrelationship between the various sectors rather than on forecasting per se, we make full use of identities and neglect transformations into log or per capita terms even if this was less satisfactory on strict theoretical grounds Similarly, the degree of disaggregation adopted reflected both the availability of data and the priorities of the thesis. For example, the trade sector is dealt with in some depth, while the consumption and production sectors are not.

The model here should be regarded, therefore, as a prototype for examination of the impact of export fluctuations on the macro-economy and not as a definitive explanation. It is hoped that it is sufficiently sensitive to capture the essential features of the process and provide us with a general picture of the TM and a basis for more detailed research. Further work will also have to be done on alternative estimation techniques. The problems raised here will be discussed more fully in 3.7.

3.2 Aggregate Demand

In this sector we consider private consumption, investment, inventories, non-cocoa exports, and imports. These expenditures, together with cocoa exports from 2.5 and budget variables from 3.4 below, provide estimates of aggregate output.

(1) Consumption

Fluctuations in exports affect the savings to income ratio, the consumption multiplier, and have longer-run implications for growth and income distribution.

Ghana experienced a high average gross savings ratio to gross national product (16.53) although it fell over time[1]. This would be consistent with precautionary behaviour in response to 'transitory' fluctuations in income. TABLE 3.1 displays the degree of income fluctuations associated with major occupations. Cocoa, forestry and fishing, and construction are particularly variable with cocoa being particularly significant by virtue of its heavy weight in employment and income[2]. The aggregate figure is, however, misleading since it ignores the transfer of savings to the government. Private consumption was constrained by heavy taxation (especially of cocoa farmers and the urban proletariat) and supply bottlenecks attributable to import controls. Rising food prices and population growth further reduced living standards for the majority of Ghanaians, despite some compensation in the form of increased social services. A further source of confusion is due to the fact that the gross figure includes external sources of saving. Despite high taxation, excess government spending resulted in a rise in internal and external debt. See 3.4 below. The internal savings ratio to gross domestic product was 11.74%[1].

Ideally one would like to test for differences in the consumption behaviour of different sectors. Those with the highest income instability might, ceteris paribus, be expected to save more. Unfortunately, however, there is no breakdown of consumption expenditure. We did estimate a Koyck distributed lag model of aggregate consumption to test for the possibility of 'permanent income' behaviour, but the coefficient on the lagged dependent variable was insignificant. We reverted, therefore, to a simple Keynesian non-proportional relationship between real consumption

Occupation[1]	I-I2
Fishing and forestry	14.1
Cocoa	12.9
Construction	11.4
Commerce	10.2
Transport	9.5
Public utilities	9.1
Manufacturing	8.5
Services[2]	7.1
Agriculture and livestock	6.7
Mining and quarrying	5.6

1. All except cocoa are calculated as total employment by industry multiplied by average monthly earnings and deflated by the price index for net national product. The cocoa figure is taken from TABLE 2.4.
2. Includes private and government services.

Source : Merritt-Brown (1972) B-2, B-3, C-3

TABLE 3.1 Real income instability by occupation 1956 to 1969 and real disposable income:

[1] $$C_t = a_{81} + a_{82}\, YD_t + e_{8t}$$

Equation [1] incorporates the simplest type of 'Pavlovian' response to variations in income in which the multiplier effect will depend on both the magnitude of income variations and the marginal propensity to consume. The estimated MPC was .62 with its associated MPS of .38 and consumption multiplier of 2.6 .

This, of course, represents only the partial multiplier effects of export fluctuations. In particular, it is naive to conclude that heavy taxation constituted a strong leakage from the circular flow of income without considering the marginal behaviour of the government, since the latter might be expected to have a high MPC out of its disposable income, as seems to be the case in Ghana for the period under consideration[3]. The strength of other non-savings leakages or 'automatic stabilizers' will be discussed more fully below.

The relatively high aggregate savings rate might also be expected to have raised the growth rate. However, there is evidence to suggest that the effective constraint on growth in this period was not savings but foreign exchange. See Killick (1978). Hence, if the 'Two Gap' analysis is correct[4], then these extra savings would be essentially redundant due to the lack of cooperating factors. The translation of savings into growth was also obstructed by poor productivity and government investment management, (see (2) below).

Income inequality tends to be relatively low in Ghana compared to most LDCS since there is no large landlord class, entrepreneurial or aristocratic elite, and extended family obligations mitigate against it. There is no evidence of an increase in urban-rural inequality, but some for a disparity between wage and salary earners in the urban sector and away from cocoa farmers to food producers in the agricultural sector[5].

The former reflects a fall in the minimum wage and a pool of unskilled labour competing for jobs. The latter is partly explained by government neglect of this group but is also due to a decline in the relative profitability and rise in risks in cocoa farming vis a vis food production.

There is little doubt that the perceived risks inherent in cocoa export dependence encouraged governments to pursue diversification. In the 1960's this meant diversification into industry and a policy of import substitution, resulting in the neglect of cocoa trees and a rise in the food import bill. Only in the 1970's did Ghanaian governments actively pursue an agriculturally-based diversification plan. The private effects of changes in income distribution were thus reinforced by government policy, but as a by-product of an industrialisation strategy, rather than a conscious evaluation of the social benefits from diversification out of cocoa production.

(2) Investment and inventories

The investment story in Ghana is not an impressive one. Despite a large capital stock, high savings ratios and a high ratio of investment to national income, growth and productivity were low and deteriorated over the period. See TABLE 3.2. The average capital to output ratio generally increased, there was significant underutilization of capacity, and this could not be justified by a gestation period for social overhead capital.

Among the reasons which have been put forward to explain this picture is poor project appraisal (often politically motivated), and the limited scope available for exploiting economies of scale presented by the small domestic market. We shall investigate two basic linkages from the export sector. The first focuses on the traditional relationship

	1957	1960	1963	1966	1969
(1) Real output per employed worker[1]	254.8	372.4	361.8	357	336.4
(2) Real average annual wage rate	259.3	305.2	267.9	209.9	232.4
(3) Total real capital per worker	224.6	329	429.1	565.1	537.6
(4) Real gross output to capital ratio	.79	.56	.43	.32	.80
(5) Real gross capital to output ratio	1.27	1.77	2.33	3.17	1.25
(6) The real average rate of profit (%)	14.42	3.56	4.09	8.49	6.34
(7) The real gross investment to output ratio (%)	15.7	20.4	20.5	20.3	13.7
(8) The real marginal capital to output ratio[2]	2.48	2.20	6.60	2.21	.81

1. Refers to a base of 1960=100.

2. Net investment.

Sources : (1) to (6) from Merritt-Brown (1972) 1-1.
(7) and (8) from Merritt-Brown (1972) D-1, F-1.

TABLE 3.2 Some productivity and investment indicators for selected years for Ghana between investment and demand, and the second on the link between investment and the supply of essential capital inputs into industry.

Fluctuations in export revenue affect demand both directly through changes in export sales, and indirectly through variations in domestic income. This second link is particularly important in Ghana since its industry was predominantly import substituting rather than exporting. If firms adjust their capital stock in line with fluctuations in demand then, given that there are lags in the adjustment process, there will be costs in terms of over and under utilization of capacity and possibly frictional unemployment.[6] Alternatively, firms might consider these adjustment costs to be greater than absorbing 'transitory' changes in demand in profits and altering their capital stock only if they consider the change in sales to be 'permanent'. If these firms are also run by expatriates, then variations in sales may be absorbed in expatriated profits rather than in employment or wages etc. In this case one would not expect a close relationship between changes in demand and investment.

TABLE 3.3 computes some simple correlation coefficients between percentage changes in some variables of interest here[7]. As expected, <u>changes</u> in exports move in sympathy with <u>changes</u> in income and employment; and changes in investment vary with changes in income. Not surprisingly, therefore, there is also a direct link between changes in exports and investment, but we shall also need to allow for some adjustment process in our equations below. Finally, we examined the relationship between changes in exports and income and net transfers of profits to the international sector. The correlation was insignificant with income but quite large and inverse with exports. In other words, transfers abroad reinforced rather than compensated export shortfalls. Ghana does not have an important expatriate sector over this period and the magnitude of such flows is small and overwhelmingly negative. Clearly the expatriate

Changes (%)						
	X	GDP	UR	I1R1	I2R2	IR
X1.P160	.90	.67	-.49	.45	.28	.5
X	1.00	.63	-.22	.29	.13	.33
	EXP					
X1.P1	-.6					
X.PX	-.59					
GDP.PGDP	.11					
	M6	M168	M5	M7	M2357	GDP
I1R1	.53	.69	-.63	.49	.12	.39
I2R2	.59	.33	.68	.51	.75	.35
IR	.62	.75	-.56	.62	.27	.43

Sources : All variables are defined in APPENDIX IV except :

EXP= Net profit incomes to the international sector. Merritt-Brown (1972) F-3-14 minus F-4-11.

IR = I1R1 + I2R2.

M168=M1+M6+M8.

M2357=M24+M3+M5+M7.

TABLE 3.3 Some correlation coefficients relating to investment behaviour automatic stabilizer envisaged by MacBean (1966) was not operative in the Ghanaian context.

The second link between exports and investment operates through the foreign exchange market. We shall suggest in 3.3 that the technology in Ghana was such that there was a very low elasticity of substitution between domestic and imported inputs into the production function. Consequently, output could be seriously constrained by the absence of such inputs. Moreover, despite import controls and foreign exchange rationing to discriminate in favour of 'essential' imports, there is evidence of severe shortages of spare parts etc. in the 1960's. See Killick (1978) chapter 10. TABLE 3.3 illustrates the relationship between variations in investment and imports, subdivided broadly into 'essential' and 'luxury' components. Not surprisingly, investment in transport, machinery and equipment is more closely related to the 'essential' category; while building and construction varies with 'luxury' imports - perhaps reflecting the relationship between buoyant home demand and a relaxation of import controls.

Finally, there is the possibility that the uncertainty arising from fluctuations in both demand and in 'essential' imports encouraged risk-averse behaviour by firms. Unfortunately, although we experimented with risk variables in the investment equations, the investment series do not distinguish between government business and non-business spending and there is no reason to expect private and public responses to risk to coincide.

Two fixed investment equations were estimated, for building and construction, and for transport machinery and equipment, respectively.

Both were based on a generalized flexible accelerator model:

[2] $$I_t = \sum_{T=0}^{\infty} \beta_T (K^*_{t-T} - K_{t-T-1})$$

where:

I = Net investment

K^* = Desired capital stock

K = The actual midyear capital stock

β = An adjustment coefficient

The problem is to determine K^* and explain the adjustment process through some form of distributed lag. From the production function discussed in 3.3, we know that the output to be produced is given by the ratio of the capital stock to a fixed coefficient V:

$$Q = \frac{K}{V}$$

If K is composed of both domestically produced and imported capital goods:

$$K = \alpha_1 K_d + \alpha_2 K_m$$

where α_1 and α_2 are distribution parameters and $\alpha_2 = 1-\alpha_1$. Consequently, output will depend upon the capital stock:

$$Q = \frac{1}{V} \cdot (\alpha_1 K_d + \alpha_2 K_m)$$

If $\alpha_1 | \alpha_2$ is a constant, then this implies a zero substitution between imported and domestic capital inputs. Assuming that domestic capital is proportional to output, while imported capital depends upon some trade variable Z:

$$K_d = v_o Q \qquad K_m = v_1 Z$$

Then the link between domestic output and imported capital is found by substitution as:

$$Q = \frac{1}{V} [\alpha_1 v_o Q + \alpha_2 v_1 Z]$$

Since we have no breakdown between domestic and imported capital, K^* is related to both output through the accelerator and essential imports:

$$K^*_t = v_o + v_1 Q_t + v_2 M7_t$$

or, combining this with a partial-adjustment mechanism for investment:

$$I_t = K_t - K_{t-1} = \beta(K^*_t - K_{t-1});\ 0 < \beta < 1$$

provides an equation of the form:

$$I_t = \beta v_o + \beta v_1 Q_t + \beta v_2 M7_t - \beta K_{t-1}$$

The link with the export sector is then completed in section (4) below when $M7_t$ is related to cocoa exports.

The two estimated equations were:

[3] $$I1\,R1_t = a_{91} V1.GDP_t + a_{92} K1_{t-1} + e_{9t}$$

[4] $$I2\,R2_t = a_{101} V2(P160.X1)_t + a_{102} K2_{t-1} + a_{103} M7_t + a_{104} V_t + e_{10t}$$

Both capital to output ratios (V1 and V2) were constructed using a straight line interpolation between troughs. For [3] GDP was used as the output measure, but real cocoa revenue was found to be superior in [4]. Essential imports were represented by real imports of transport machinery and equipment and V is included as a measure of the tightness of money. In addition, we tried out a number of risk measures from APPENDIX I to test for possible risk aversion. However, we could find no significant relationship. We were left, therefore, with an investment process which goes beyond a simplistic

'Pavlovian' correlation of investment and exports and builds into it the costs of adjustment of actual to optimum stock, and the linkages between investment and the export sector through an accelerator and a variable representing capital imports.

To complete this part of aggregate demand we need to specify depreciation expenditures and inventories. For building and construction investment, the capital stock series was constructed on the assumption of a constant rate of depreciation of five percent. See Merritt-Brown (1972,43).

[5] $$R1_t \equiv .05\, K1_{t-1}$$

For transport, machinery and equipment, depreciation expenditures were estimated as:

[6] $$R2_t = a_{11}K2_{t-1} + e_{11t}$$

With regard to inventories, there was a discrepancy between the aggregate of real visible and nonvisible imports by SITC categories and the figure from the national accounts data. Consequently, to ensure consistency in the income identities, the residual was added to inventories. Attempts to fit a simple accelerator model to the inventory data proved unsatisfactory and so real inventories were left exogenous.

(3) Other exports

Given the constant value of total exports of goods and non-factor services from the national accounts data and the real value of cocoa exports from the cocoa subsector, non-cocoa exports were derived as a residual:

$$X2 \equiv X - (P160.X1)$$

X2 was then regressed on a real income variable for developed countries and the real effective exchange rate facing non-cocoa exports. The result however, although significant, was poor in terms of $\bar{R}^2(.56)$ and added noticeably to forecasting error when included in the simulations of Chapter 4. Hence we omitted this equation from the model and took X2 to be exogenously determined.

(4) Imports

The imposition of controls in 1962 raises problems in the construction of import equations since the control regime was inefficient and generally unable to resist the pressures of aggregate demand on licences[8]. Consequently, allowance had to be made for the influence of income and relative prices as well as for the structural split in the time period. Nine components were specified in real terms according to SITC categorisation, with invisibles and one miscellaneous category left exogenous. Details on the construction of the relative price variables is relegated to APPENDIX V.

In the food import equation we used real GDP and a price variable covering the control period:

$$[7] \quad MO_t = a_{121} + a_{122}GDP_t + a_{123}\left(\frac{PMO.TO}{P6}\right)_t \cdot D6269 + e_{12_t}$$

For beverages and tobacco the real disposable income variable was significant only in the non-control period. A trend variable was added to capture the change in the composition of imports resulting from the creation of domestic substitutes from 1955 to 1962:

$$[8] \quad M1_t = a_{131} + a_{132}YD_t.D5662 + a_{133}T.D5662 + e_{13_t}$$

With regard to crude materials (other than fuels), animal and vegetable oils and fats; the explanatory variable was the ratio of the capital stock for transport, machinery and equipment, to non-cocoa output. This is a proxy for capacity utilization. Attempts to include income and price variables proved unsatisfactory:

$$[9] \quad M24_t = a_{141} + a_{142}\left(\frac{K2}{GDP - (P160.X1)}\right)_t + e_{14_t}$$

Mineral fuels, lubricants and related items, were explained by the number of registered vehicles and a dummy variable reflecting a sharp fall in this category between 1961 and 1966:

$$[10] \quad M3_t = a_{151}VEH_t + a_{152}D61646566 + e_{15_t}$$

In the equation for chemicals, both the income and relative price variables were significant over the whole period:

$$[11] \quad M5_t = a_{161}YD_t + a_{162}\left(\frac{PM5.T5}{PC}\right)_t + e_{16_t}$$

Manufacturing imports and miscellaneous manufacturing imports were lumped together and determined by GDP and net private short-term capital flows. Price and income variables were insignificant.

$$[12] \quad M68_t = a_{171}CSP_t + a_{172}GDP_t + e_{17_t}$$

Imports of machinery, transport and equipment, were best explained by real cocoa exports, real disposable income and a dummy for 1962:

[13] $$M7_t = a_{181} + a_{182}(P160.X1)_t + a_{183}YD_t + a_{184}D62 + e_{18t}$$

The part that imports play in the TM depends upon both their role in the circular flow of income and on the magnitude of other automatic stabilizers operating through the balance of payments, especially those relating to foreign exchange reserves and capital transfers from abroad. We shall deal with the balance of payments as a whole when we consider the government and concentrate here on the narrower relationship between exports and imports. TABLE 3.4 suggests that both luxury and essential imports tended to vary with exports, in spite of the avowed policy of rationing exchange in favour of essential imports earmarked for import substituting industries. Quotas were perhaps effective in ensuring that the exchange problem did not deteriorate further, but they were unable to prevent shortages of supplies to industry or resist the pressure of demand on consumers' goods imports. Paradoxically, the use of import controls is likely to increase the value of the multiplier since they reduce the marginal propensity to import and ensure a greater domestic impact from any autonomous injection into the income stream. There is also the possibility of inflationary pressure on domestic prices in the absence of a sufficient supply of domestic substitutes for imports.

The traditional 'leakage' function of imports in the TM, however, ignores the stimulatory effect that imports of essential goods has on growth, especially where the elasticity of substitution between domestic and imported inputs into the production function is close to zero. This was especially important in Ghana since it was government

Changes (%)	M6	M8	M168	M7	M2357
X1.P160	.64	.67	.75	.59	.53
X	.42	.66	.59	.54	.52

Sources : X1.P160, X and the import categories are defined in APPENDIX IV or in TABLE 3.3.

TABLE 3.4 Some import correlation coefficients policy to encourage capital intensive methods of production. In so far as shortfalls in exports were reflected in shortages of essential imports, and this was translated into excess capacity in industry and agriculture, then the effects on growth were detrimental. The dependence of investment on imports of essential goods (M7) has been raised in (2) above. In the model, M7 was itself explained by cocoa exports and disposable income.

3.3 Aggregate Supply

In this section we discuss the relationship between output, employment and factor income. Aggregate employment and annual average wage equations are estimated and combined to derive labour income. Unfortunately there is no data for sectoral value-added which, together with employment in each sector, could have provided sectoral production functions.

(1) Output

During the 1960's Ghana was developing a small but rapidly growing import substituting manufacturing sector through central planning and imported capital goods. Output is given by aggregate demand from 3.2 so employment is demand determined i.e. the production function is used to specify that output required to satisfy demand and to derive the quantity of labour needed to produce that output, given the stock of capital and technology available. In general if:

$$Q = F(N, K, T)$$

where:

Q = The output to be produced

K = The capital stock

N = The level of employment

T = The level of technology

then:

$$N = F\ (Q, K, T)$$

and the level of unemployment is given by :

$$U = L - N$$

where L refers to the labour force. If employment is demand determined then N represents the demand for labour services i.e. both the number of persons and the number of hours worked. If K and T can be approximated by a time trend and we ignore the complications introduced by differences between 'normal' hours and overtime rates[9], the desired demand for labour services can be approximated by a log-linear relationship:

[14] $$\text{Log } L^*_t = \alpha_o + \alpha_1 \text{ Log } Q_t + \alpha_2 \text{ TIME}$$

Given labour force adjustment costs, it is likely that actual employment will move only gradually to the desired level i.e. costs rise with the speed of adjustment and uncertainty precludes complete adjustment. We assume a partial adjustment mechanism in which these costs vary with the amount of unemployment, which is itself a proxy for the state of the labour market. When unemployment is high, firms are able to re-hire skilled labour when conditions improve and so avoid losses from training costs incurred earlier. The reverse holds when unemployment is low. In this model the lagged unemployment rate μ is used as an indicator of market conditions:

[15] $$\frac{L_t}{L_{t-1}} = \left(\frac{L^*_t}{L_{t-1}}\right)^{\lambda} e^{\beta\mu_{t-1}}, \quad 0 < \lambda \leqslant 1$$

where β and λ are parameters[10].

Taking logs and substituting [14] into [15] yields:

[16] $$\text{Log } L_t = \lambda\alpha_o + \lambda\alpha_1 \log Q_t + \lambda\alpha_2 \text{ TIME} + (1-\lambda) \text{ Log } L_{t-1} + \beta\mu_{t-1}$$

Accordingly, the following equation was estimated:

[17] $$LNE1_t = a_{191} + a_{192}\text{TIME} + a_{193}\ LNNNP1_t + a_{194}\ LNE1_{t-1} + a_{195}\ UR_{t-1} + a_{196}\ D66 + e_{19t}$$

A dummy was included to allow for lay-offs resulting from the coup in 1966 as part of a policy of restraint by the NLC.

The time trend and a series for the capital stock proved insignificant. Consequently the model collapses into a fixed coefficient production function with parameters u and v:

$$Q = \frac{K}{v} = \frac{L}{u}; \quad u, v > 0$$

so that:

[18] $$Q = \min\left(\frac{K}{v}, \frac{L}{u}\right)$$

If capital represents the effective constraint on production[11] i.e. K/v is the minimum of [18] then:

$$Q = \frac{K}{v}; \text{ and } L^* = uQ$$

where L* represents the required labour supply. Hence [14] is reduced to:

[19] $$\text{Log } L^*_t = \alpha_o + \alpha_1 \text{Log } Q_t$$

and [16] becomes:

[20] $$\text{Log } L_t = \lambda\alpha_o + \lambda\alpha_1 \text{ Log } Q_t + \beta\mu_{t-1} + (1-\lambda) \log L_{t-1}$$

This provides the following estimating equation:

[21] $$LNE1_t = a_{201} + a_{202}\ LNNNP1_t + a_{203}\ UR_{t-1} + a_{204}\ D66 + a_{205}\ LNE1_{t-1} + e_{20t}$$

A linear version was also estimated for experimentation in simulation, with the dummy and constant omitted as insignificant.

[22] $$E1_t = a_{211} + a_{212}\ NNP1_t + a_{213}\ UR_{t-1} + a_{214}\ D66 + a_{215}\ E1_{t-1} + e_{21t}$$

As far as the TM is concerned, we have already mentioned the influence of exports on aggregate demand and the supply of capital inputs into production. The model set up above assumes a zero elasticity of substitution between inputs in the production function and thus places the burden of adjustment on output and employment. It was once thought that the 1960's witnessed a marked rise in unemployment, due to the combination of a rapid increase in population and static growth in output. However, this may have been a little exaggerated, since the average unemployment rate over the period was about 8%; although it was as high as 11% between 1966 and 1969 and does not allow for 'disguised' unemployment in agriculture[12]. TABLE 3.5 offers some evidence that unemployment varies inversely with changes in GDP and also with exports, since changes in GDP and changes in exports are themselves closely correlated. The relationship between income changes and unemployment is weakened, of course, by the lack of representation in these indices of the sort of adjustment mechanism incorporated in the equations above.

(2) Factor income

The average annual wage per head was made a function of the price of output. At less than full capacity the production relationship implies that the marginal and average products of labour are equal to the real wage and the coefficient on the price variable is an estimate of the average productivity of labour. A constant is included to reflect the minimum wage, and dummies to capture the rise in the share of wages in net national product resulting from the creation of state farms and corporations in 1961 and 1962, and the raising of the minimum wage from 1960 onwards:

[23] $$W_t = a_{221} + a_{222}\,PNDP_t + a_{223}\,D6069 + a_{224}\,D6162 + e_{22t}$$

An attempt to include a food import price variable proved unsatisfactory. There was also the possibility that rises in export earnings encouraged wage pushes which were not matched by symmetric falls in wages in bad years. A casual analysis of the data did not support this view.

Changes (%)	GDP	UR					
X1.P160	.67	-.49					
X	.63	-.22					
GDP	1.0	-.51					

	W	AP	EXP	WS	PS	IS	GS
GDP.PGDP	.45	.16	.11	-.32	.16	-.32	.01
X1.P1	-.13	.01	-.6	.11	-.03	.31	.40
X.PX	.0	-.16	-.59	.06	-.23	-.04	.46

Sources : X1.P160, X, GDP, UR, W, PGDP, P1, and PX are defined in APPENDIX IV.

EXP=Net transfers abroad by property and enterprise.

WS, PS, IS, GS, are shares to the wage sector, property and enterprise, the international sector, and the government, respectively from Merritt-Brown (1972) F-3, F-4.

AP is the average rate of profit from Merritt-Brown (1972) 1.1.

TABLE 3.5 Some correlation coefficients for the supply sector

As far as the distribution of factor income is concerned, the profit rate has tended to fall over time but is highly volatile. See TABLE 3.6. Wage rates have remained quite stable and have generally risen over time, but the real wage rate declined after 1961, so that its value in 1969 was lower than in 1956. These facts are indicative of the poor growth performance of the economy, but we are also interested in seeing whether there are any systematic relationships between factor shares and aggregate income and export revenue. TABLE 3.6 shows the distribution of income between wages, profits, government revenue, and international transfers; and TABLE 3.5 presents some correlation coefficients between changes in rewards and changes in aggregate income and export revenue. There is a little evidence that wage rates move with money national income but not profit rates. Current net transfers to the international sector by property and enterprise are small in magnitude but are destabilizing with regard to current export revenue. There is no evidence of any systematic variation in income shares, with the possible exception of government disposable income, which shows signs of sympathy with export revenue. This is not surprising since a large portion of government revenue is derived from the export sector. The importance of this leakage will be considered in more depth in the next section.

Finally, to complete the supply picture, three identities were specified defining unemployment, the unemployment rate and total labour income:

[24] $$U \equiv L - E1 - E2$$

[25] $$UR \equiv \left(\frac{U}{L}\right) . 100$$

[26] $$W1 \equiv W.E1$$

	(1) Real wage rate cedis	(2) Profit rate (%)	(3) Wage share (%)	(4) Profit share (%)	(5) Government share (%)	(6) International share (%)
1956	246	22	75	12	12	.5
1957	259	14	78	9	13	.3
1958	269	9	78	7	15	.4
1959	276	13	76	10	14	.3
1960	305	4	83	3	14	.3
1961	318	-6	93	-8	14	1
1962	293	-4	94	-6	11	1
1963	267	4	85	3	12	1
1964	234	11	72	12	14	1
1965	218	7	76	9	14	1
1966	210	8	75	13	10	.8
1967	224	6	79	10	10	1
1968	227	6	80	9	10	1
1969	233	6	79	9	11	.7

Sources : (1) The real annual average wage per head in business and government business. Merritt-Brown (1972) 1-1.

(2) The average rate of profit. Merritt-Brown (1972) 1-1.

(3)-(6) are shares to the wage sector, property and enterprise, the international sector, and the government, respectively. All are expressed as a percentage of total income. Merritt-Brown (1972) F-3, F-4. Row sums reflect rounding error.

TABLE 3.6 Factor income in Ghana 1956 to 1969.

3.4 The Government Sector

This section considers the government's role in the economy. In (1) we define a number of equations explaining the revenue and spending components of the budget, linked together with a set of identities. In (2) we discuss the implications of government behaviour for the TM.

(1) The budget

On the revenue side, equations are specified for both indirect taxes on production and consumption and direct taxes on income. Indirect taxes comprise cocoa export duties, import duties, duties on non-cocoa exports, and a miscellaneous category of indirect taxes.

For cocoa exports an average tax rate was constructed as a function of the actual tax schedule employed:

$$\begin{aligned} TX1 &= 1.0(P1 - 344.5)X1 && \text{if } P1 > 520 \\ &= .5(P1 - 168)X1 && \text{if } 380.1 \leqslant P1 \leqslant 520 \\ &= .5(P1 - 100)X1 && \text{if } 240 \leqslant P1 \leqslant 380 \end{aligned}$$

In other words, if Ghana's export price exceeded 520 cedis per ton, then the difference between exports valued at the export price and exports valued at 344.5 cedis per ton, is taxed at 100%. Over the period, P1 never fell below 240 cedis per ton.

Accordingly, the schedule was estimated as:

[27] $$\begin{aligned} TX1_t = {} & a_{231}(P1 - 344.5\ .X1)_t.D1 \\ & + a_{232}(P1 - 168\ .\ X1)_t.\ D2 + a_{233}(P1 - 100\ .X1)_t.\ D3 \\ & + e_{23t} \end{aligned}$$

where D1, D2 and D3 are dummies assuming the value of unity in those years in which the condition in the tax schedule was satisfied.

For import duties, tax revenue collected is made a function of total imports and dummies representing exceptional increases in revenue:

[28] $$TM_t = a_{241} M_t + a_{242} D6264 + a_{243} D65 + e_{24t}$$

Taxes on non-cocoa exports are related to the current value of non-cocoa exports from 1956 to 1964 and dummies for 1962 and 1963.

[29] $$TX2_t = a_{251} + a_{252} (X2.PX)_t \cdot D5664 + a_{253} D6263 + e_{25t}$$

Turning to taxes on income, personal taxes on wages and salaries are regressed on total labour income:

[30] $$TY1_t = a_{261} + a_{262} (W1 + W2)_t + e_{26t}$$

Data was not available for the components of profit income, so an aggregate equation for taxes on non-wage income was estimated using the income of property and enterprise. Dummies were included for 1961 to 1962 and for 1966. The former reflects the introduction of a provisional tax assessment scheme (improving tax collection methods) and the increase in state run farms and corporations in 1961. The latter allows for the effects of the coup.

[31] $$TY2_t = a_{271} Y1_t + a_{272} D6162 + a_{273} D66 + e_{27t}$$

Taxes on the miscellaneous category were regressed on net domestic product:

[32] $$TI1_t = a_{281} + a_{282} (PNDP.NDP)_t + e_{28t}$$

The sales of government goods and services to wage and salary earners was made a function of the disposable income of wage and salary earners. A dummy for 1967 to 1969 was included to allow for the transfer of government enterprise from the non-business to the business sector.

[33] $$S1_t = a_{291} YD1_t + a_{292} D6769 + e_{29t}$$

Government sales to property and enterprise were left exogenous given the unreliability of the income data.

Two elements of government spending are endogenised: consumption spending and interest on the national debt, and transfers to the household sector. The former is related to nominal GDP and cocoa exports, and the latter to population, export taxes and a dummy for 1968.

[34] $$GA_t = a_{301} + a_{302}\ PGDP.GDP_t + a_{303}\ P1.X1_t + e_{30t}$$

[35] $$TR1_t = a_{311} + a_{312}\ N_t + a_{313}\ D68 + a_{314}\ (TX1+TX2)_t + e_{31t}$$

To close the sector we require some identities:

[36] $$TI \equiv TX1 + TX2 + TM + TI1$$

[37] $$TY \equiv TY1 + TY2 + TY3 + S1 + S2$$

[38] $$TR \equiv TI + TY$$

[39] $$G \equiv GA + SUB + TR1 + TR2 + TR3$$

[40] $$S \equiv TR - G + VC$$

[40'] $$GYD \equiv TR + VC - (PD + SUB + TR1 + TR2 + TR3)$$

(2) The transmission mechanism

The role of the government in the TM depends upon the extent of its dependence on trade revenues, the degree of fluctuation in those revenues relative to other sources of government income, and its policy response to such fluctuations. Clearly, the authorities will be interested both in variations in its revenues per se, and in variables associated with Ghana's external position. We begin with the budget.

TABLE 3.7 presents the percentage contribution of different taxes to total current revenue, and the latter as a percentage of gross national product. Ghanaians are taxed more heavily on average than other developing country citizens , and the government is taking an active role in the economy. Moreover, a large portion

Income :	(%)
Personal	8.05
Company	9.53
Government business and capital	4.16
Government sales of goods and services	8.35
Production and consumption :	
Cocoa export taxes	21.03
Other taxes on exports and imports	29.51
Purchase, sales, excise and property Taxes	11.55
Fines, fees, licences and miscellaneous	7.82
Total current revenue as a proportion of GNP	16.29
Source : Merritt-Brown (1972) 1.2.	

TABLE 3.7 The average percentage contribution of different taxes to total revenue 1956-1969.

of its revenue comes directly or indirectly from the trade sector. Cocoa contributes not only through export duties but also through voluntary contributions by cocoa farmers to the development plan, income taxes, and payments from the Cocoa Marketing Board to the government. There is also a link between cocoa exports and the tax base for import duties, since cocoa revenue is a prime determinant of import capacity; although this was less important in the early years given ample foreign exchange reserves and the availability of supplier credits.

TABLE 3.8 ranks the sources of government revenue by degree of instability from high to low measured by the normalised standard deviation. It is noticeable that taxes on exports rank high in the order. This emphasises again the point made in 2.1 (2) that it is inappropriate to focus only on the stability of aggregate exports in value terms. The equivalent statistic for the current value of cocoa exports is .16, and for exports as a whole, .37. TABLE 3.8 examines the correlation between revenue components to see if shortfalls in one area are offset by rises in others. Cocoa export taxes, it seems, are not significantly compensated for by any other element of revenue, even though they account for 36% of total taxes in 1960.

Since the export of cocoa is controlled by a marketing board mechanism, one interesting question is whether, on balance, income from the Cocoa Marketing Board was stabilizing or destabilizing in its impact on government revenue. This will depend on the variance (σ^2) and covariance (ρ) of Cocoa Marketing Board income and other income since :

$$\sigma_R^2 = \sigma_{R1}^2 + \sigma_{R2}^2 + 2\rho\sigma_{R1}\sigma_{R2}$$

$$R \equiv R1 + R2$$

Normalized standard deviation

VC[1]	1.96	TY	.40
TI1	.70	TI	.38
TX1	.55	TM	.37
TY2	.55	S1	.35
TY1	.55	S2	.34
TX	.53	TX2	.30
GRC	.50	TI2	.29
GRNC	.42	GYD	.28

Simple correlation

	TX2	TM	TI1	TY1	S1	S2	TI2
TX1	-.21	-.27	.32	.28	-.34	-.06	.44

	TX	TT
TX[2]	1.0	.41
GRC	.87	.34

1. The sample was small for this variable.
2. TX was used here since it is highly correlated with TX1 (.99). TX=TX1+TX2.

Sources : All variables are defined in APPENDIX IV except :
GRC=TX+VC; TT=TI+TY.
GYD= Government current disposable income.
GRNC= Non-cocoa revenue.

TABLE 3.8 The instability of government revenue and the inter-relationship between its components where:

R1 = Receipts from the Cocoa Marketing Board

R2 = Other receipts

The stability of government revenue thus depends upon the size of the variances of R1 and R2 but also on their covariance, since a large negative covariance could neutralize the individual variances in total income. Unfortunately, no data is forthcoming to enable the separation out of the contribution of the Cocoa Marketing Board; but instead, R was divided into government revenue from cocoa (GRC) and non-cocoa revenue (GRNC). The normalised standard deviation was higher for GRC (.50) than for GRNC (.42) and there was a low positive covariance between the two sources of income (.17).

There are a number of possible ways in which the government might respond to variations in its budget revenue. Since taxation was relatively heavy in Ghana, this would imply a strong leakage from the income flow if the authorities maintained spending constant while receipts fluctuated; especially if taxation was strongly progressive. This is the type of automatic stabiliser suggested by MacBean in his colonial model. An alternative is that the government responds in a countercyclical fashion by varying spending inversely with income.

From TABLE 3.9 there was a trend rise in revenues over the period[13] but also a general rise in current spending. Hence, except for between 1963 and 1965, the government surplus tended to fall. This was reflected in borrowing from the private sector and an increase in foreign debt. From TABLE 3.10 current spending and investment spending generally moved in sympathy with revenue but the relationship is not as strong as one might have expected. The correlation between government investment and import taxes might be explained by the fact that an increase in investment would suck in

	Total revenue (000)	Current spending (000)	Current surplus (000)	External debt (000)	Internal debt (000)
1956	106784	55497	27120	6400	38400
1957	115156	61719	32069	6400	37400
1958	133950	70851	40450	6600	34200
1959	138253	78266	39543	12000	33082
1960	146576	92711	37538	12700	76500
1961	160267	110769	29025	16400	108200
1962	163011	108525	4047	25500	171800
1963	184207	117566	10274	38300	275000
1964	225535	135082	48777	346800	323900
1965	294699	148331	62957	378400	407100
1966	256647	121182	40113	395300	464700
1967	263176	142201	5190	484000	514000
1968	302010	171026	-10864	493000	563600
1969	343935	194035	16377	496200	604200
	Source : Merritt-Brown (1972) E-6.				

TABLE 3.9 The budget position in Ghana 1956-1969

Changes (%)

	TX	TM	TT	GYD	GRC	GRNC
GA	.42	.52	.71	.75	.34	.53
IG	.15	.71	.69	.62	.09	.66

	X1.P1	X.PX
GA	.73	.11
IG	.70	-.03
SUB	.69	-.04
F	.12	.11
RS	-.03	.23
CSP	.17	.21
CLP	.18	-.06
CP	-.25	.19
CG	.11	.15

Sources : F and RS refer to (3) and (4) respectively in TABLE 3.11.

CLP, CP and CG relate to private long-term net direct investment, total short and long-term private net capital flows, and net government capital transfers, respectively. All are taken from Merritt-Brown (1972) G-1.

TT, GRC, and GRNC are defined in TABLE 3.8.

All other variables are defined in APPENDIX IV.

TABLE 3.10 Some correlation coefficients for the government sector imports and therefore raise import revenue. The role of revenue in explaining government spending was allowed for by including cocoa exports in the regression equations above.

Turning to the direct relationship between trade and government spending; current spending, investment spending and subsidies all vary quite closely with current cocoa export revenue, but not with any other trade variable. A closer inspection of the relevant series suggests that the relationship is asymmetric i.e. when revenue rises this is associated with a rise in government activity, but when it falls there is a fall in activity only in the crisis years of 1962 and 1966. The outcome of this 'ratchet' effect was an expansion of activity when cocoa revenue rose and relaxation of import controls (for example in 1965, 1969 and 1970) reflected in a rise in domestic and foreign debt, balance of payments crises, and inflation. In 1966 and 1972 there were political repercussions in the form of military coups. The Ghanaian government, therefore, did not act countercyclically (except during a crisis) nor respond in a passive manner when faced with fluctuations in its revenue.

One final aspect of budget behaviour is the possibility that uncertainty about government revenue encouraged risk averse behaviour in investment and planning. Although Ghanaian policy-makers have always been aware of their susceptibility to changes in the world cocoa market, the Nkrumah regime consciously did not restrict its industrialization plans to the constraints imposed by the budget or foreign exchange market, but were prepared to absorb shortfalls in domestic and foreign debt. Indeed, an important motive for industrial growth itself was to reduce dependence on cocoa exports.

The NLC and successive governments adopted the strategy of diversification but at a pace more in conformity with the budget and exchange constraints. Investment and planning were accordingly more cautious, but the authorities were still unable to contain a consumer boom in the wake of favourable cocoa receipts in 1969 and 1970.

Successive governments in Ghana, therefore, tended to be over-optimistic rather than risk-averse. The costs were reflected in crisis adjustment and cuts in investment. We attempted to endogenise government investment and test for the effects of fluctuations in revenue using the instability measures defined in APPENDIX I, but no significant results were obtained [14].

As far as the external position is concerned, Ghana experienced a deficit on current account in every year except 1958, financed initially by a fall in reserves accumulated in the 1950's and subsequently by a net capital inflow. Since net private foreign investment was negligible and the major component of aid went to the Volta River Project, this meant an increase in the debt-service ratio and, after 1961, a position of fundamental disequilibrium (see TABLE 3.11). In 1962 import controls were imposed and preference given to essential imports. Medium-run loans and suppliers credits were arranged. The situation, however, deteriorated and the International Monetary Fund was called in. Nkrumah refused to accept the stabilization measures proposed and in 1966 he was replaced by the NLC. The currency was devalued by 30% in 1967, deflationary measures introduced, and negotiations started with regard to the rescheduling of existing debt and provision of longer-run economic aid.

There are a number of reasons for this sad picture. To begin with, Ghana was living beyond its means in the 1960's and was unable to generate sufficient savings to finance an ambitious policy of centrally controlled

	(1) Current balance (000)	(2) Capital balance (000)	(3) International liquidity (000)	(4) Increase in reserves (000)
1956	-26000	38000	326600	2000
1957	-28000	14000	278500	-6000
1958	20000	-12000	287000	6000
1959	-22000	38000	310400	18000
1960	-54000	60000	283500	12000
1961	-99316	-36208	159100	-149878
1962	-56529	55853	162900	-3240
1963	-91626	48840	124600	-49030
1964	-67326	55488	125200	-18624
1965	-230200	175500	135200	-44200
1966	-128700	95600	128700	-29900
1967	-86600	29400	102200	-53700
1968	-51500	40600	114900	-5200
1969	-58300	60800	88900	-2700

Sources : (1), (2) and (3) are from Merritt-Brown (1972) G-1.

(4) is from Merritt-Brown (1972) G-2.

TABLE 3.11 The balance of payments in Ghana 1956 to 1969 industrialisation, made worse by an increase in population. Much of the blame lies squarely at the feet of government. The currency was overvalued until 1967 and the effective exchange rate for imports was above the official rate while below it for exports. This discouraged exporting and stimulated import substitution but still left a strong incentive to import due to domestic inflation. Poor coordination between internal and external policy meant that devaluation in 1967 was not accompanied by contraction of aggregate demand. Import controls were poorly administered and private foreign investment and aid were discouraged by exchange controls on expatriated profits over the whole period.

A major explanation, however, is the stagnant trend in exports, notably cocoa. The barter terms of trade generally deteriorated (due to a fall in cocoa prices), although the income terms of trade were more stable due to the offsetting movements in price and quantity. This does not, of course, mean a constant import capacity, since it ignores the increase in population and in overseas debt. There is good reason to suggest that Ghana represents a classic foreign exchange constrained economy in the 1960's[15]. Lack of exchange meant a shortage of essential imports, underutilisation and disruption of output, and a reduction in investment in later years. Export diversification policy failed to reduce dependence on cocoa or on trade in general, and shortages of imported inputs and a low real producer price resulted in insufficient investment to maintain growth[16]. There was no case for a rapid increase in supply since this would have lowered prices further, but sufficient growth to maintain market share was justified.

What then was the balance of payments adjustment mechanism in response to export instability? Ghana was unable to maintain international liquidity and reserves declined continuously over the period (see TABLE 3.11). Yet as TABLE 3.10 shows, reserves did not accommodate exports, nor were there any compensating movements in capital flows. Given the absence of an expatriate sector automatic stabilizer referred to in 3.2 (2), this meant that a significant portion of the adjustment was shouldered by imports of luxury and essential goods. The costs involved have been discussed in 3.2 (4), but some additional ones might be mentioned at this juncture. The import control system itself was costly in terms of the diversion of scarce administrative resources to the balance of payments and away from growth. The erratic supply of import licences, combined with stop-go cycles in government policy, must have generated considerable uncertainty in industry; particularly given its dependence on inputs from the import sector. Finally, cuts in food imports and the resulting inflationary pressures on domestic food prices, must have reinforced the downward drift in real cocoa farmers' incomes and exacerbated the small size of the domestic market through reductions in the demand for manufactured goods. The stability of export revenue in aggregate, therefore, understates the importance of export fluctuations within the context of a government committed to rapid import substituting growth and subject to a foreign exchange constraint reflecting deteriorating cocoa export performance.

3.5 The Monetary Sector

From 1950 to 1959, and covering the early part of our period, Ghana was on a Sterling Exchange Standard with currency issue 100% sterling backed. Consequently, the money supply tended to vary directly with the balance of payments, although the commercial banks often remained passive. From 1960 onwards Ghana issued its own currency and hence acquired the ability to vary its money supply independently of the balance of payments by using the Central Bank to cover budget deficits.

In this thesis a modified quantity theory was adopted[17] on the grounds that the financial market in Ghana is relatively backward (despite some progress over the period); the authorities tended to hold interest rates fixed; the income velocity of circulation remained fairly constant over the period; and attempts to estimate a more sophisticated demand for money function proved unsuccessful.

Since gross domestic product is given by the aggregate demand sector, once the money supply (MS) and income velocity of circulation (V) are explained, the absolute price level is given from the quantity equation:

$$PGDP = \frac{MS.V}{GDP}$$

In this model, both MS and V are explained endogenously. The first is based upon the familiar multiplier relationship between the supply of currency and deposits (MS) and 'high-powered' money (H) consisting of currency and bank reserves[18].

$$MS = KM.H$$

Although we tried to relate H to the government debt, the trade balance, and the level of reserves, the final estimating equation assumed a trend rate of increase:

[41] $$H_t = a_{321} + a_{322}\ TIME + e_{32_t}$$

The money multiplier was determined by the fraction of the money supply in currency (CM) and the commercial banks' reserves to deposits ratio (RD).

[42] $$KM_t = a_{331} + a_{332}\, CM_t + a_{333}\, RD_t + e_{33_t}$$

CM was itself related to the level of bank activity per capita and a dummy variable for 1967 to 1969. The former accounts for the substitution of cheque deposits for currency as a means of payment, while saving and time deposits substitute for currency as a store of value. The latter reflects the stabilization policy of the NLC.

[43] $$CM_t = a_{341} + a_{342}\left(\frac{B}{N}\right)_t + a_{343}\, D6769 + e_{34_t}$$

RD was in turn related to cocoa output, nominal GDP and two dummies. One represented the uncertainty in 1959 about future policy prior to the formation of the Republic in 1960, and one to account for the introduction of a new scheme for financing cocoa in 1963.

[44] $$RD_t = a_{351} + a_{352}\, QSC1_t + a_{353}\, PGDP.GDP_t + a_{354}\, D59 + a_{355}\, D63 + e_{35_t}$$

Finally, V was endogenised in terms of the bank density variable representing the opportunity cost of holding money (given the risk of fire, theft etc.). Attempts to relate it to an inflation variable approximating expectations about the rate of change of the value of money proved unsuccessful, as was an attempt to include a real income variable.

[45] $$V_t = a_{361} + a_{362}\left(\frac{B}{N}\right)_t + e_{36_t}$$

As far as the TM is concerned, there are perhaps two key links with the monetary sector. Firstly, whether monetary policy was influenced by movements in trade variables; and secondly, whether export fluctuations affected aggregate activity via the money market.

From 1950 to about 1959 the money supply tended to vary with the balance of payments under the Sterling Exchange Standard [19]. But from 1960 onwards there was a significant increase in spite of stabilization measures by the NLC. Consequently we could not explain the supply of high powered money in terms of trade or budget variables. In absolute terms MS did not decrease at all over the period. TABLE 3.12 looks at the correlation between percentage changes in monetary variables and trade and budget variables. Not surprisingly, the relationship is not very strong since, although improvements in trade or domestic income are associated with an expansion in monetary activity, shortfalls are not reflected in a contraction. The negative sign implies that when income did fall, the deficit was partly paid for by deficit financing. In absolute terms, of course, nominal gross domestic product and the money supply are positvely connected (.98) through the quantity identity. Once again, the adjustment is through asymmetric changes in the money supply rather than through a passive policy or countercyclical variations when export revenue varied.

The link between the export sector and the price level is a complex one. Up to 1961 inflationary pressures could be absorbed in the balance of payments by running down reserves; but after this date there was a noticeable acceleration in inflation which began to spill-over into domestic prices. This was in spite of import and price controls. The average annual increase in the price of gross domestic product was 5.6% over the whole period and 7.1% after 1967 . To what extent the rise in prices was due to deficit financing is unclear since there were other sources of pressure. Most important, perhaps, were food shortages (made worse by import controls) and excess demand due to structural imbalances in the import substituting sector which was

Changes (%)

	P1.X1	TX	GRC	RS	BOT
H	-.03	-.29	-.32	.06	-.48
MS	-.02	-.52	-.47	-.28	-.45

Sources : All variables have been defined in previous tables, or are done so in APPENDIX 1V, except BOT which represents the balance of trade, from Merritt-Brown (1972) G-1.

TABLE 3.12 Some correlation coefficients for the monetary sector unable to satisfy the domestic demand for goods previously imported. Consequently, only in 1965 was there a clear link between deficit financing, the money supply, and inflation. See Killick (1978) Chapter 6.

There is no evidence of any significant cost-push pressures from the cocoa sector, and indeed this sector acted as a deflationary stimulus, since cocoa incomes were held down. Real wages in manufacturing remained fairly constant, although money wages rose by an average of 7% per annum. The major impact on inflation from the export sector thus found expression through aggregate income increases not matched by deflation when revenue fell, and exacerbated by import controls made necessary by a shortage of foreign exchange.

3.6 The Price Sector

In this sector, equations are specified for the consumption and fixed investment elements of aggregate demand. The export price of cocoa has already been determined in the cocoa subsector. All import prices were taken as exogenous together with those for government consumption and non-cocoa exports. In the absence of data on the price of inventcries, the nominal value of inventories was derived as a residual from the nominal gross domestic product identity.

The price deflator for private consumption spending is explained by a liquidity variable showing the pressure on prices from aggregate demand and the monetary sector, and a dummy for 1966 when prices rose dramatically.

[46] $$PC_t = a_{371} + a_{372}\left(\frac{MS}{GDP}\right)_t + a_{373}\,D66 + e_{37t}$$

In view of the large proportion of investment goods that are imported, both investment price equations included their relevant import price series. However, for building and construction this proved unsatisfactory, and instead the lagged price for building and construction was used together with the liquidity proxy.

[47] $$P2_t = a_{381}\left(\frac{MS}{GDP}\right)_t + a_{382}\, P2_{t-1} + e_{38t}$$

[48] $$P3_t = a_{391} + a_{392}\,(PM7.T7)_t + e_{39t}$$

The link between the export sector and prices has already been discussed in 3.5, but one or two extra comments are pertinent here. The inclusion of the liquidity variable in the price equations is designed to capture the pressures from aggregate demand and the money supply, and hence indirectly, the impact of export changes. Another possible link, however, is that a fall in cocoa revenue leads (via a fall in foreign exchange) to a shortage of food imports and hence to a rise in food prices. To test this hypothesis, food imports were correlated with cocoa and total exports, but there was no significant relationship. The inclusion of an export variable in [48] also proved unsatisfactory.

3.7 Estimation

The equations assembled in chapters 2 and 3 constitute a simultaneous equation model. It contains within it a number of endogenous or jointly dependent variables and a number of exogenous variables. If OLS is applied to an equation in the model there will usually be more than one current endogenous variable in the relation and whichever variable is selected as 'dependent', the remaining endogenous variable(s) will generally be correlated with the disturbance term in the equation so the resulting estimates will be biased and inconsistent. Only in the case of recursive models will OLS provide an optimal estimating technique.

A number of methods exist to achieve consistency, applied either to each equation individually (limited information methods), or to the system as a whole (full information methods). Examples of the former are two stage least squares (2SLS) and instrumental variables (IV); and of the latter are three stage least squares (3SLS) and the full information instrumental variable efficient (FIVE) method of Brundy and Jorgenson (1971). Some of these methods can also be combined with an autocorrelation correction (usually first-order only) factor.

The choice of technique(s) in model estimation therefore depends on the computational costs involved and on an evaluation of the suitability of the particular method for the particular model under investigation. Research is far from conclusive on this issue since there is no widely accepted methodology for deriving conclusions about the properties of alternative estimators, and empirical studies tend to be model specific. For a textbook review of work in this area, see Johnston (1972), and for the methodological problems involved, Hendry (1974). It is generally considered that OLS has the greatest finite sample bias and that inferences based upon it should be treated with caution. Nonetheless, it is common practice to adopt OLS in the context of simultaneous equation models in view of its ease of computation and interpretation and its small sample properties, in particular its small variance around the mean in small samples and where there is a suspicion of mis-specification. 3SLS, on the other hand, is rarely applied even where the sample is large, since it displays sensitivity to errors in one equation feeding through into others, especially where nonlinearities are present.

The OLS results for both the cocoa subsector and the macroeconomy are tabulated in APPENDIX VI together with some appropriate statistics. The results are very good for the cocoa subsector. Omitting the 'complex' form of the cocoa supply function [23] all the equations portray an $\bar{R}^2$ greater than or equal to .85. All the coefficients are 'robust' and there is no evidence of first-order autocorrelation. The first version of inventory behaviour [30] is more significant than the second [31], but both were retained for simulation. The performance of the macroeconomy is more mixed but generally satisfactory given the complexity of the model and the data available. As far as aggregate demand is concerned, the consumption function and most of the import equations proved to be the most disappointing, although the worst equation [9] was later omitted because of its undesirable simulation properties. The simpler, non-log, supply function [22] was adopted for simulation in view of its better overall fit on the F statistic compared to the other two alternatives [17] and [21]. The equations in the government sector and price sector are good, but the overall fit for the velocity of circulation [45] in the monetary sector is poor. Equations [6] and [45] also displayed serious autocorrelation and were corrected using the Cochrane-Orcutt procedure. Since this had to be done by hand, it was decided not to extend this to some of the other equations where there was only a suspicion of serial correlation.

APPENDIX VII lists the corresponding parameter estimates produced by applying 2SLS and a generalisation of the limited information instrumental variable efficient method of Brundy and Jorgenson (1974). For the macro model 3SLS is inappropriate since the number of explanatory variables greatly exceeds the number of observations. LIVE is a compromise between the greater efficiency of the full information methods and their greater computational expense, and is particularly useful if the sample is small in relation to the model size. It is equivalent to the first iterate of Lyttken's iterative instrumental variables, both of which are less efficient than full information methods. The properties of LIVE are discussed in Brundy and Jorgenson (1974). The approach was as follows :- a static simulation (i.e. where the lagged dependent variables retain their observed values) was performed using the OLS parameter estimates. Then the simulated values of the jointly-dependent variables were used as instrumental variables in an instrumental variables estimation of the model. The results are consistent. The gain in efficiency is attained by repeating the steps starting with a static simulation using the consistent coefficient estimates. Note that most of the coefficients converged after this second iteration.

For the cocoa subsector the 2SLS and LIVE estimates are similar to,but generally better than,their OLS counterparts. The exception being the live estimates for equation [33] . For the macroeconomy, however, most of the equations are worse and in the case of [1] it is totally unacceptable. The simulation properties of these alternative methods are discussed in the next chapter, but in view of the ambiguity surrounding their relative merits, in our simulation experiments we decided to remain on the side of caution and rely on the OLS estimates. We would have liked to have carried out more research on the properties of alternative estimators, but this would have required considerably more resources than were currently available to us. In particular, our statistical package enabled us only to compute OLS and 2SLS estimates. The LIVE steps had to be computed by us individually.

Notes

1. The figures were computed from Merritt-Brown (1972). Gross savings were for households and business (including government business) and government savings. The variables were in nominal terms to facilitate international comparison. The equivalent mean average propensity to save for a sample of 16 Latin American countries was 13.9. See Mikesell and Zinser (1973). For the internal ratio see Merritt-Brown (1972).
2. The equivalent figure for cocoa from Merritt-Brown is 10.3. However since it refers only to wage-earners it might not be representative of cocoa instability in general.
3. Killick (1978,28) believes this to be true. A regression of current government saving on current government disposable income produces a marginal propensity to save of .19. When a constant was included the coefficients were insignificant on both variables. There are problems, however, in defining the saving variable. See Mikesell and Zinser (1973).
4. See 1.2 (2) above.
5. See Killick (1978).
6. For a classic statement of the possible harmful effects of export fluctuations on investment, see Nurkse (1958).
7. These coefficients are only intended as a rough measure of association. Since many of the variables displayed no strong trends, this crude measure was preferred to some of the more complex methods listed in APPENDIX I.
8. For a discussion of the control regime, see Killick (1978).

9. See Brechling (1965).

10. Abbey and Scott Clark (1974) employed the same partial adjustment mechanism and derived a fixed coefficient production function from a Cobb-Douglas function having disregarded a capital stock series because its coefficient turned out to be insignificant. For some background to demand for labour functions and the problems associated with them, see Ireland and Smyth (1967).

11. This is plausible for Ghana given dependence on imported capital, although there may have been shortages of specific types of skilled labour up to about 1966 before the fruits of previous educational policies materialised. See Killick (1978,180).

12. For more details on the unemployment situation see Killick (1978).

13. The tax ratio increased despite adverse world cocoa prices and a tax structure which is very inelastic with regard to money gross national product. A fall in the ratio in the early 1960's was due almost entirely to falls in cocoa revenue (while the ratio of non-cocoa tax revenue remained stable) since the rate of duty on cocoa is highly progressive with respect to the world price, despite cuts in the farmer price. See Killick (1978,148).

14. There is a problem here in separating out government consumption and investment spending.

15. See 1.2 (2) above.

16. See Bateman (1970).

17. For this we rely heavily on Abbey and Scott clark (1974).

18. MS includes currency and deposits with banks (demand and time); post office savings; and building society deposits. H includes currency, vault cash, and deposits with the Bank of Ghana.

19. The rise in the money supply from 1956 to 1959 was associated with a rise in international liquidity.

CHAPTER 4 : SIMULATION

In this final chapter, the equations contained in the econometric model constructed in Chapters 2 and 3 are assembled and solved as a complete system, with the aid of a computer simulation programme. In 4.1 we briefly justify the usefulness of simulation in the context of export instability. In 4.2 the equations selected for the final 'control' solutions of the model are listed and the various steps in the simulation procedure are summarised. Finally, in 4.3 the results of the analysis are evaluated and the implications for the TM are examined.

4.1 The Role of Simulation

Simulation is a technique employed for a variety of reasons in econometrics, including model testing and evaluation, historical analysis, and forecasting[1]. In the context of this thesis its prime role is to obtain a numerical solution to the simultaneous set of equations describing the Ghanaian economy over the time period 1956 to 1969, and to investigate the dynamic properties of the model. There were a number of reasons why it was chosen in preference to alternative techniques.

To begin with, it is convenient computationally to solve the model numerically in view of the time lags and nonlinearities present. Secondly, simulation enables us to gauge how the system functions as a whole, since an individual equation might have a good statistical fit when considered in isolation, but may perform badly when treated as part of a larger model. The converse may also be true. Hence, simulation facilitates 'sensitivity' analysis on the key parameters and provides 'feedback' information to the original model. This is especially important for the problem of export instability, since we are interested in tracing the dynamic repercussions of export fluctuations and obtaining a 'feel' for the TM, rather than in obtaining an 'optimal' solution to a particular problem.

Another virtue of the technique is that it allows us to carry out repeated solutions of the model using different values for the parameters based on alternative estimation methods. Even though we are not primarily concerned here with evaluating the general performance of these methods, we are interested in the likely margin of error implied by the use of OLS.

Similarly, we might be interested in analysing the time paths of specific endogenous variables conditional upon alternative 'decision rules' pertaining to the exogenous variables in our model. For example, the impact on aggregate income of alternative assumptions about the real producer price of cocoa based upon various stabilisation regimes.

Finally, and perhaps the most important justification for simulation in this thesis, relates to multiplier analysis. Within the simulation model we are able to calculate dynamic multipliers which quantify the impact of exogenous 'shocks' in the export sector on particular endogenous variables, and compare these shocks with those originating from elsewhere in the system. If our model adequately captures the structural features of the economy over the historical time period, and the behavioural equations reflect the responses of the various key 'actors', then these multiplier values will be indicative of the consequences of export instability.

Moreover, stochastic simulation enables us to go one step further by examining the probability distribution of these multiplier values through replicated experiments. Since the equations of an econometric model are estimated by fitting them to data, the resulting parameter estimates are themselves random variables. In addition, each equation has an implicit additive error term associated with it. Stochastic simulation allows us to recognise this random character of the model and the simulation and forecast errors it implies.

4.2 The Solution Procedure

(1) The econometric model

Thirty-three equations and twenty-five identities were selected for the control solutions of the model. As regards the cocoa subsector, the forecast equation [37] was used for Ghanaian cocoa output and the first inventory function [30] was preferred to the alternative [31] in view of the latter's higher simulation forecast error. The cocoa export quantity equation [33] also generated large errors, despite a good fit as an individual equation.[2] Since this error feeds through into real cocoa export revenue, its inclusion could produce a distorted view of the performance of the rest of the model. However, it is an important link in the TM. Consequently, we decided to take X1 as exogenous in the basic control solution of the whole model, but include it for the purposes of multiplier analysis and when considering the cocoa submodel in isolation.

As far as the macro-model is concerned, non-cocoa exports were taken as exogenous as a result of a poor statistical fit, and the simple linear form of the employment function [22] was included. When we came to solve the model, the investment equation for building and construction and the equation for imports of crude materials produced 'looping' effects which precluded convergence. We tried to alter the ordering of the equations but to no avail. Since the problem seemed to stem from the simultaneity with GDP, we replaced this variable in the investment equation by real cocoa export value [3']. We have no satisfactory substitute for the import equation and so we omitted it.

The equations[3]: a) the cocoa subsector :

[37] $$QSC1_t = a_{21}\ CONSTANT + a_{22}\ PF_{t-5} + a_{23}\ PF_{t-8} + a_{24}\ TIME$$

[25] $$QDC_t = a_{31}\ CONSTANT + a_{32}\left(\frac{PCW}{PUS}\right)_t + a_{33}\ YOECD_{t-1}$$

[30] $$\left(\frac{PCW}{PUS}\right)_t = a_{41}\ CONSTANT + a_{42}\left(\frac{SC}{QDC}\right)_t$$

[32] $$P1_t = a_{61}\ (PCW/PUS.PUS/100)_{t-1}$$

The cocoa export equation used in some of the analysis is included here as an extra equation:

[33] $$X1_t = a_{71}\ QSC1_t + a_{72}\ D64$$

The equations : b) the macroeconomy:

[1] $C_t = a_{81}\ \text{CONSTANT} + a_{82}\ YD_t$

[3'] $I1R1_t = a_{91}\ V1(P160.X1)_t + a_{92}\ K1_{t-1}$

[4] $I2R2_t = a_{101}\ V2(P160.X1)_t + a_{102}\ K2_{t-1} + a_{103}\ M7_t + a_{104}\ V_t$

[6] $R2_t = a_{111}\ K2_{t-1}$

[7] $MO_t = a_{121}\ \text{CONSTANT} + a_{122}\ GDP_t + a_{123}\left[\frac{PMO.TO}{P6}\right]_t .\ D6269$

[8] $M1_t = a_{131}\ \text{CONSTANT} + a_{132}\ YD_t.D5662 + a_{133}\ T.D5662$

[10] $M3_t = a_{151}\ VEH_t + a_{152}\ D61646566$

[11] $M5_t = a_{161}\ YD_t + a_{162}\left[\frac{PM5.T5}{PC}\right]_t$

[12] $M68_t = a_{171}\ CSP_t + a_{172}\ GDP_t$

[13] $M7_t = a_{181}\ \text{CONSTANT} + a_{182}\ (P160.X1)_t + a_{183}\ YD_t + a_{184} D62$

[22] $E1_t = a_{211}\ NNP1_t + a_{212}\ UR_{t-1} + a_{213}\ E1_{t-1}$

[23] $W_t = a_{221}\ \text{CONSTANT} + a_{222}\ PNDP_t + a_{223}\ D6069 + a_{224}\ D6162$

[27] $TX1_t = a_{231}\ (P1 - 344.5.X1)_t.D1 + a_{232}\ (P1 - 168.X1)_t.D2 + a_{233}\ (P1 - 100.X1)_t.D3$

[28] $TM_t = a_{241}\ M_t + a_{242}\ D6264 + a_{243}\ D65$

[29] $TX2_t = a_{251}\ \text{CONSTANT} + a_{252}\ (X2.PX)_t.D5664 + a_{253}\ D6263$

[30] $TY1_t = a_{261}\ \text{CONSTANT} + a_{262}\ (W1 + W2)_t$

[31] $TY2_t = a_{271}\ Y1_t + a_{272}\ D6162 + a_{273}\ D66$

[32] $TI1_t = a_{281}\ \text{CONSTANT} + a_{282}\ (PNDP.NDP)_t$

[33] $S1_t = a_{291}\ YD1_t + a_{292}\ D6769$

[34] $$GA_t = a_{301}\ CONSTANT + a_{302}\ PGDP.GDP_t + a_{303}\ P1.X1_t$$

[35] $$TR1_t = a_{311}\ CONSTANT + a_{312}\ N_t + a_{313}\ D68 + a_{314}\ (TX1 + TX2)_t$$

[41] $$H_t = a_{321}\ CONSTANT + a_{322}\ TIME$$

[42] $$KM_t = a_{331}\ CONSTANT + a_{332}\ CM_t + a_{333}\ RD_t$$

[43] $$CM_t = a_{341}\ CONSTANT + a_{342} \left(\frac{B}{N}\right)_t + a_{343}\ D6769$$

[44] $$RD_t = a_{351}\ CONSTANT + a_{352}\ QSC1_t + a_{353}\ PGDP.GDP_t + a_{354}\ D59 + a_{355}\ D63$$

[45] $$V_t = a_{361}\ CONSTANT + a_{362} \left(\frac{B}{N}\right)_t$$

[46] $$PC_t = a_{371}\ CONSTANT + a_{372} \left(\frac{MS}{GDP}\right)_t + a_{373}\ D66$$

[47] $$P2_t = a_{381} \left(\frac{MS}{GDP}\right)_t + a_{382}\ P2_{t-1}$$

[48] $$P3_t = a_{391}\ CONSTANT + a_{392}\ (PM7.T7)_t$$

The identities: a) the cocoa subsector :

[34] $$QSC_t \equiv QSC1_t + QSC2_t$$

[35] $$SC_t \equiv QSC_t - QDC_t + SC_{t-1}$$

[36] $$P160X1_t \equiv (P1_t.X1_t)/P_t.100$$

The identities[4]: b) the macroeconomy :

[49] $$NDP_t \equiv C_t + I1R1_t + I2R2_t + I3_t + GC60_t + P160X1_t + X2_t + R3_t - M0_t - M1_t - M24_t - M3_t - M5_t - M68_t - M7_t - M9_t - M1060_t$$

[5] $R1_t \equiv .05K1_{t-1}$

[50] $GDP_t \equiv NDP_t + R1_t + R2_t$

[51] $MS_t \equiv KM_t . H_t$

[52] $PGDP_t \equiv (MS.V)_t / GDP_t . 100$

[53] $PGDPGDP_t \equiv (PGDP.GDP)_t / 100$

[54] $PNDP_t \equiv \left[(PGDP.GDP)_t - (P2.R1)_t - (P3.R2)_t \right] / \left[(GDP-R1-R2)_t \right]$

[55] $NNP_t \equiv NDP_t + (CSX - CSM + LSX)_t / PNDP_t . 100$

[56] $NNP1_t \equiv NNP_t - (W2/PNDP.100)_t$

[36] $TI_t \equiv TX1_t + TX2_t + TM_t + TI1_t$

[37] $TY_t \equiv TY1_t + TY2_t + TY3_t + S1_t + S2_t$

[38] $TR_t \equiv TI_t + TY_t$

[39] $G_t \equiv GA_t + SUB_t + TR1_t + TR2_t + TR3_t$

[40] $S_t \equiv TR_t - G_t + VC_t$

[40'] $GYD_t \equiv TR_t + VC_t - (PD + SUB + TR1 + TR2 + TR3)_t$

[24] $U_t \equiv L_t - E1_t - E2_t$

[25] $UR_t \equiv (U/L)_t . 100$

[57] $YD_t \equiv (CSX - CSM + LSX - GYD - NTI + NDP.PNDP/100)_t / PNDP_t . 100$

[58] $YD1_t \equiv (YD.PNDP)_t / 100 - YDPE_t$

[59] $$M_t \equiv \Big[(PM0.M0)_t + (PM1.M1)_t + (PM6.M24)_t + (PM3.M3)_t + (PM5.M5)_t + (PM6.M6)_t + (PM7.M7)_t + (PM8.M8)_t + (PM8.M9)_t + (PM10.M1060)_t \Big] / 100$$

[60] $$PNDPNDP_t \equiv PC_t . C_t + I1R1_t . P2_t + I2R2_t . P3_t + I3NOML_t + P4_t . GC60_t + P1_t . X1_t + PX_t . X2_t + R3NOML_t - M_t$$

[26] $W1_t \equiv W_t . E1_t$

(2) The simulation model

Since the model is simultaneous and nonlinear in the variables, a variant of the Gauss-Seidal iterative procedure was used, contained in a multipurpose simulation package called HASH.[5] We first carried out some ex post historical simulations over the sample period using the OLS parameter estimates. These represent unconditional simulations in which the actual values of the exogenous variables are used to perform a static one step ahead solution with the lagged endogenous variables retaining their initialized values.[6] Four basic control solutions were thus produced : for the cocoa subsector, both with and without X1; for the macroeconomy with cocoa variables exogenous; and for the model as a whole.

We next carried out a number of experiments to gauge the dynamic properties of the model and to test some hypotheses about the TM. To begin with we considered alternative methods of estimating the equations. For the cocoa submodel we repeated the control simulations using the 2SLS and LIVE estimates of APPENDIX VII. For the macroeconomy, 2SLS was inappropriate, so we confined ourselves to LIVE. To investigate the dynamic stability of the model we repeated the control solutions (OLS) for the cocoa submodel (minus X1) and for the macroeconomy, with the lagged dependent variables not constrained to their initialized values.

The next stage consisted of the calculation of dynamic multipliers obtained by 'shocking' selected exogenous variables in turn and assessing the deviation of the disturbed solutions from the undisturbed control solutions. This enables us to examine the impact of autonomous changes in exogenous variables on the time path of selected output variables. Multipliers were calculated on the basis of changes in the exogenous variables which were sustained over the entire period. In all cases, the shock was set at five per cent of the starting value of the exogenous variable.

To allow for a stochastic dimension, we carried out fifty simulations of the cocoa model (including X1) and the macroeconomy, but added to the equations, random variables with normal deviates from a zero mean multivariate normal distribution and standard deviations equal to the estimated standard errors of the OLS regressions. We then calculated the mean values of the multipliers over all the runs and the standard deviations of these mean values from their respective control equivalents.

Finally, we carried out some counterfactual exercises with regard to the real producer price of cocoa and real cocoa export earnings. In Chapter 1 we raised a number of doubts concerning the appropriateness of using cross-section aggregate measures of instability, and the likely margins of error introduced when condensing all the information contained in a time-series into a single statistical measure of deviation from some norm or average. We can, to some extent, overcome this weakness by using the actual time-series in a control simulation run and then comparing the outcome with alternative stability regimes. These regimes might vary between the extremes of a fully fledged buffer stock model with a given set of operation rules, and an arbitrary steady state constant or smoothed growth path. In between, there is room for pragmatic elimination or significant reduction of fluctuations. We confined ourselves here to a relatively simple counterfactual in which PF was transformed into a smoothed version based on the following time trend:[7]

$$PF' = \alpha_o + \alpha_1 T + \alpha_2 T^2 + \alpha_3 T^3$$

This data was substituted into the cocoa model, which was then solved on the basis of the unchanged historical parameters.

We then repeated the procedure for real cocoa export earnings where[7]:

$$P160X1' = \alpha_4 + \alpha_5 T + \alpha_6 T^2$$

As a last experiment, we replaced the values of PF by an alternative series representing what the farmer would have received had the Cocoa Marketing Board not operated to shield him from the world market[8]. We then compared the control solution for the cocoa submodel with the run using this latter series.

4.3 Evaluation

(1) The simulation results[9]

In this section we evaluate the results from the simulation analysis described above. In (1) we concentrate on the presentation and interpretation of the control solutions under alternative estimation methods, and static and nonstatic conditions. In (2) we switch our attention to multiplier and counterfactual analysis, which has a direct bearing on the TM.

TABLE 4.1 assesses the overall goodness-of-fit of our control solutions using the root mean square error and the absolute mean error, both in levels and in first differences. The alternative estimates for the equation coefficients using 2SLS and LIVE are listed in APPENDIX VII. APPENDIX VIII describes the simulation tracking performance of the individual equations under the alternative control solutions[10]. We use Theil's inequality coefficient $(\hat{U})$ and its decomposition into inequality proportions, together with the percentage average tracking error (AE) and percentage root mean squared error (RMSE). The latter is a better measure if there are large positive and negative errors which cancel.

Control solution	A.P.R.M.S.E. (a)	A.P.R.M.S.E. (b)	A.P.A.M.E. (a)	A.P.A.M.E. (b)
Cocoa subsector, with X1, static solution, 1956-1969	30.7353	67.1417	.3857	41.6783
Cocoa subsector, minus X1, static solution, 1956-1969	25.7104	61.1319	.3806	28.6579
Macroeconomy, static solution, 1957-1969	40.9535	100.2865	1.4713	78.6981
Cocoa subsector and macro-economy, static solution, 1957-1969	40.1539	108.5949	1.1360	68.7604
Cocoa subsector, minus X1, static solution, 2SLS, 1956-1969	25.7244	61.1620	.3803	28.7969
Cocoa subsector, minus X1, static solution, LIVE, 1956-1969	25.5067	60.5418	.3794	27.2811
Macroeconomy, static solution, LIVE, 1957-1969	48.6532	110.2410	1.9340	86.2480
Cocoa subsector, minus X1, nonstatic solution 1956-1969	32.2649	70.0866	.7265	24.9237
Macroeconomy, nonstatic solution, 1957-1969	41.2848	99.9547	1.4029	84.2477

(a) = Levels A.P.R.M.S.E. = Average % root mean square error

(b) = First differences A.P.A.M.E. = Average % absolute mean error

TABLE 4.1 Overall tracking performance of the simulation model.

The results for the cocoa submodel are quite satisfactory, but noticeably better when X1 is exogenously determined, when all endogenous variables display $\hat{U}$ less than unity; although the covariance proportion UC is quite high for some of the variables, and the price variables generate higher RMSE's.

The overall performance of the macroeconomy and the complete model is still quite good considering the complexity of the relationships involved, but the individual tracking records for many of the dependent variables are disturbingly poor. Twenty-one out of fifty-one for the macroeconomy exhibit a $\hat{U}$ above unity, and eleven have RMSE's exceeding sixty. S in particular performs badly ($\hat{U}$ = 5.9483) as does C, MO, UR and U (RMSE's > 70). UC is again quite high in most of the equations. The implications are perhaps less important for S and UR since they do not enter as arguments into other equations or identities.

The analysis thus clearly indicates scope for improvement in certain areas of the model. One immediate way to do this would be to linearise more of the equations, and substitute simpler forecasting equations for those which perform badly. However, since we are primarily concerned here with approximating the TM rather than in building a forecasting model per se (in which forecasted levels of the variables are important), there is little room for improvement without further experiments upon our basic theoretical equations or access to better quality data. Consequently, we decided to continue with the model as it stood, but bearing in mind these 'feed-back' implications from our simulation analysis.

When we repeated our control solutions using the alternative parameter estimates from 2SLS and LIVE, the results were marginally better for the cocoa subsector, but worse for the macroeconomy. As far as individual equations were concerned in the macroeconomy, some improved their fit using LIVE, but many became noticeably worse. (See APPENDIX VII). We continued, therefore, to remain on the side of caution and rely on our OLS estimates.

Since the model contains some lagged dependent variables (PCW/PUS, SC, UR, E1, P2) we repeated the control runs in a nonstatic context. The macroeconomy results were hardly affected, but the cocoa model tracking statistics were worse, particularly for P160X1 and QDC. None of the important multipliers derived below, however, appeared significantly altered if we reverted to a static mode.

(2) Implications for the transmission mechanism

APPENDIX IX presents the results of our nonstochastic multiplier calculations, in which selected endogenous variables are subjected to sustained shocks of five percent in selected exogenous variables. It would be tedious to present all the multiplier combinations contained in a model of this size, so we restricted our attention to the repercussions of the cocoa subsector and trade sector in general, and contrasted them with two variables representative of domestic government policy tools. We looked at all of the dependent variables in the cocoa subsector, but for the macroeconomy chose a number of variables relating to the important indicators of economic activity, including income, government revenue and spending, investment, imports, and unemployment[11].

For the cocoa subsector we considered the effects of a change in the real producer price of cocoa (PF), in the incomes of consuming countries (YOECD), and in the rest of the world output of cocoa (QSC2).

The immediate consequence of an increase in PF in 1956 would be to increase Ghanaian cocoa output, and hence world output, in two bursts: one of about 6% in 1961 and a second of about 15% in 1964[12]. This reflects the lagged response of output to changes in farmer prices. There follows three separate mechanisms which combine to produce the net effect on real cocoa export earnings (P160X1). The first is an increase in the quantity of exports (X1) by approximately 6% from 1961 to 1963, and by 15% from 1964 to 1969. The second operates through an increase in stocks of cocoa which rise steadily from 1961 onwards and depress the world price (PCW/PUS) and, with a lag, Ghana's export price (P1). Finally, the fall in price itself exerted a positive stimulus to cocoa demand (QDC).

Hence, the eventual net impact on P160X1 depends on the relative strengths of these three mechanisms. Since demand is relatively inelastic (increasing by .36% in 1961 to a maximum of 3% in 1969), and the impact on prices is strong (P1 falls from 1.7% to 15.8% over the period 1962 to 1969), then the eventual fall in P1 easily outweighs the increase in X1 and QDC. Until the price effect materialises, earnings rise (by 6% in 1961, 1% in 1962, 4.5% in 1964), but from 1965 onwards, earnings fall continuously by about 10% per annum.

A contrasting story emerges from a rise in YOECD. The induced rise in consumption demand (QDC) (after a lag) is relatively weak, due to the low income elasticity of demand; but the rise in PCW/PUS and P1 is strong in the absence of increases in supply. Hence stocks (SC) fall steadily (5.7% to 30%), and P1 rises in 1958 by 4% and continuously to 12.5% in 1969[13]. As a consequence, P160X1 rises by an annual average of 19% from 1959 onwards, with a peak of about 35% in 1966.

Finally, there is the impact of a rise in rest of the world output to consider. The immediate effect is to generate a rise in stocks (8.6% to 47%), and eventually to produce a significant fall in prices. Since QDC is relatively inelastic (increasing between 1% and 3.3%), and Ghana's export quantity (X1) is unaffected, the steady fall in P1 (4% to 17.6%) induces a decrease in P160X1 averaging 25% per annum. This, however, overstates the case in so far as we have not made X1 sensitive to the fall in P1; but given Ghana's market share (see TABLE 2.3), and the weak elasticity of demand with respect to price, the compensation is not likely to be very significant.

The upshot in the cocoa market, therefore, is that changes in YOECD and QSC2 have unambiguously opposite effects on Ghanaian cocoa export earnings. The impact of changes in PF, however, is more complex and depends to some degree on the lag between the rise in output and the dampening influence of stock accumulation on prices. The root of the problem lies in the cobweb response of output and the inelasticity of demand. Whether an alternative price 'regime' will influence these outcomes will be discussed below; but meanwhile, we need to consider the implications of these exogenous changes in cocoa market variables, together with some additional ones originating in the macroeconomy at large, for the Ghanaian economy as a whole.

The rise in PF, operating through P160X1 and separately through P1 and X1, has a lagged effect on GDP after five years (1.7%), and again after eight (1.4%); but eventually depresses income by an annual average of 1.7% for the latter four periods as export prices adjust to clear the market[14]. There are similar repercussions on other aggregate variables in the latter years: GYD falls by 10% per annum, I2R2 by 6%, and S by a staggering 37%. Imports (M) offer only a minor leakage in the circular flow of income, falling by 1.6% per annum. Unemployment (UR) rises by about 6% per annum.

Because a five percent increase in YOECD has such a multiple impact on P160X1, its eventual consequences for income, employment, investment and budget variables are significant and in the same direction. From 1959 to 1969, the annual average rise in GDP would be 6% per annum. The equivalent figures for the other variables are: GYD (13%); G (1%); S (36%); I1R1 (23%); I2R2 (53%); M (8%); and UR (-35%).

Changes in the opposite direction result from a rise in QSC2, again operating through P160X1. For most variables, the peak is reached in about 1965 or 1966, and then the multiplier effects diminish. GDP falls by an annual average of 7% from 1958 to 1969. The figures for the other variables are: GYD (-15%); G (- 1.2%); S (-45%); I1R1 (- 27%); I2R2 (- 62%); M (- 9%); UR (+ 42%).

Since the influence of these cocoa variables operates primarily through P160X1[15], it would be useful to examine directly the implications of a multiplier change in P160X1 on the macroeconomy, sustained every year from 1957 to 1969. From APPENDIX IX GDP would increase by an annual average of 1.7%, with the following effects on the other variables: GYD (1%); G (0.0%); S (2.8%); I1R1 (6%); I2R2 (15%); M (2%); UR (- 10%). Note that the influence on budget variables is underestimated to the extent that P1 and X1 no longer feed into tax and government spending functions. However, if we take as an approximation that a five percent direct increase in P160X1 is roughly akin to a 1% rise in YOECD[16] (due to its multiple impact through export price), then the increase in GYD would be something of the order of 3% per annum; G would rise by about .24%; and S by 9%.

One cannot escape, therefore, from the strong feeling that fluctuations emanating from the cocoa market have important linkages with the macroeconomic performance of the Ghanaian economy, even if we allowed for some margin of error. The multiplier effects operate not only through their direct effect on the components of aggregate demand; but also indirectly through the foreign exchange market on imports of 'essential' goods, investment and employment. To the extent that we have been unsuccessful in endogenising government spending and monetary policy to any significant extent with regard to cocoa market or trade variables, and in fact they were sensitive to pressures from the cocoa market, these multipliers may understate the consequences of export fluctuations.

To put this into some sort of perspective, we examined the corresponding multiplier effects of other trade and budget variables.

From APPENDIX IX it is clear that short-term private capital flows (CSP), exports of capital services (CSX) and net transfers to the international sector (NTI), have relatively marginal effects on the domestic economy in contrast to the cocoa market.

A five percent change in CSP has a maximum impact on GDP in 1967 of .02%; that of CSX (in 1957) of .05%; and of NTI (in 1957) of -.01%. If the government chose to increase its sales of goods and services to property and enterprise (thus increasing its revenue) the depressing impact on GDP would have been at a maximum of -.01% in 1957. If, on the other hand, it decided to increase its real consumption spending by an equivalent amount, it would have succeeded in raising GDP by an annual average of .56% per annum from 1957 to 1969. The impact on other variables would be: GYD (.24%); S (.68%); I2R2 (1.9%); M (.56%); UR (-2.9%). These effects are by no means insignificant, but emphasise the relatively important part that cocoa plays in the Ghanaian economy.

Having constructed the econometric model of Ghana and reproduced (albeit imperfectly) the historical time paths of its endogenous variables, one is tempted to go a step further and pose counterfactual questions. The potential scope for such questions is enormous, but three, in particular, appealed to us within the context of the export instability debate. What would have happened if the real producer price of cocoa had been stabilised around a particular trend line? What if the farmer had been rewarded in line with variations in the real world price instead of the one paid to him by the Cocoa Marketing Board? What if Ghana's real cocoa export earnings had followed a more stable trend path than actually occurred?

TABLE 4.2 presents the results from the three counterfactual exercises. Comparing the trend adjusted real export earnings with the control solution (which produces what actually happened) one finds that the smoother series would involve a cumulative loss of earnings of about 12.14 million cedis from 1961 to 1969, or

	P160X1 control	Trend PF	PF=PCW/PUS
1956	101.93	101.93	101.93
1957	107.76	107.76	107.76
1958	78.67	78.67	78.67
1959	145.91	145.91	145.91
1960	168.57	168.57	168.57
1961	180.10	172.27	159.50
1962	172.03	170.58	179.39
1963	181.99	180.49	201.25
1964	154.98	154.85	127.58
1965	199.92	198.98	199.99
1966	205.89	202.41	223.57
1967	165.49	162.48	162.72
1968	127.75	126.97	116.84
1969	152.07	150.47	132.07
Total net gain NC (000,000)		- 12.14	- 12.45
Per annum 1961-1969 NC (000,000)		- 1.3	- 1.4

	GDP control	Trend P160X1
1957	855.22	827.70
1958	791.30	866.38
1959	840.45	901.79
1960	910.95	947.07
1961	960.84	923.73
1962	1103.9	1066.6
1963	1080.2	1073.1
1964	1055.0	1079.9
1965	1141.9	1012.0
1966	1148.5	1140.8
1967	1062.7	1120.1
1968	1031.7	1050.3
1969	1006.1	1018.0
Total net gain NC (000,000)		38.3
Per annum 1957-1969 NC (000,000)		2.9

TABLE 4.2 Counterfactual analysis with the simulation model

1.3 million per annum. Before 1961, the impact of the alternative price series has no effect on P160X1, since it is not until that date that changes in QSC1 are forthcoming. The reason for this result seems to lie in the fact that the substitution of the smoother price series does not much alter output decisions, since it moves very closely with the original series. A comparison of the forecasting errors for QSC1 in the two cases confirms this[17]. This need not have happened had we chosen an alternative method of trend correction, and this emphasises the importance of the choice of stabilisation regime. A smoother series, per se, is no guarantee of a better earnings stream.

As far as the second question is concerned; it appears from TABLE 4.2 that Ghana would not have been better off in export revenue terms if it had paid farmers in line with fluctuations in the world price of cocoa. The net loss comes to 12.5 million cedis or 1.4 million per annum. The reasons are embedded within the lag structure of the model, and the relative ups and downs of the two series.

The final question refers directly to export earnings. If Ghana could somehow have stabilised her real export revenue along the particular trend line fitted above[7], then from TABLE 4.2 this would have generated a net gain over the <u>entire</u> period of 38.3 million cedis, or approximately 3 million per annum.

The implications of this limited counterfactual analysis are that neither the substitution of the real world price, nor an alternative smoother series, would have raised Ghana's net earnings; but the <u>particular</u> trend line we fitted to export earnings would have raised her GDP per annum in the region of about .3% of the mean of the control GDP series. Clearly, then, the benefits of 'stability' compared to the actual control series depend , not only on the econometric relations contained in the model (allowing, where relevant, for behaviour under uncertainty), but also on the precise form of the stabilisation regime. To achieve an 'optimal' time path for cocoa earnings or GDP, will require experiments with alternative series for variables such as PF and P160X1.

To round off our simulation analysis, we carried out fifty stochastic simulations of the cocoa submodel (including X1) and the macroeconomy, in order to ascertain the margin of error associated with our multiplier analysis. To keep the analysis within the bounds of our computational resources, we based our conclusions on two key multipliers: P160X1 in the cocoa market, and GDP in the macroeconomy. We computed the mean for each variable over the simulation runs and their standard deviation from the mean of their control solution. The results are presented in TABLE 4.3 . In all cases the deviation from the respective control mean diminished as the number of simulations increased. The magnitude of the errors does not, in our view, seriously obviate the results derived above.

	PF	YOECD	QSC1
P160X1 control mean	-2.97	16.92	-23.82
25 simulations :			
Mean	-4.62	25.01	-11.93
SD	2.61	6.30	6.46
50 simulations :			
Mean	-3.19	18.61	-18.64
SD	2.39	6.19	5.73

	P160X1	YOECD	QSC2	PF
GDP control mean	15.74	48.86	-62.96	-2.50
25 simulations :				
Mean	19.32	21.43	-152.04	-1.50
SD	1.67	13.98	11.83	5.96
50 simulations :				
Mean	16.41	40.01	-84.39	-.87
SD	1.60	11.61	11.00	5.61

	CSP	CSX	NTI	GC60	S2
GDP control mean	.155	.260	-.066	4.750	-.042
25 simulations :					
Mean	.002	1.460	1.630	2.490	1.060
SD	.005	.030	.006	.095	.005
50 simulations :					
Mean	.096	.470	-.034	3.970	-.120
SD	.003	.021	.005	.093	.003

TABLE 4.3 Stochastic multipliers for GDP and P160X1

Notes

1. For an excellent introduction to the applications of simulation to economics, see Pindyck and Rubinfield (1976).
2. See APPENDIX VIII for the magnitude of the forecasting errors. The criteria used are discussed below.
3. The numbers refer to the relevant estimating equations and identities in chapters 2 and 3. Hence, the cocoa subsector numbers all refer to chapter 2 and the macroeconomy numbers to chapter 3. Some additional identities have also been added, running sequentially from [49] to [60].
4. Time subscripts have been added to avoid confusion.
5. The package originated in work undertaken as part of the Southampton Econometric Model, under the direction of Professor I. Pearce. See Harrison and Smith (1977).
6. Prior to the solution procedure, all variables are initialized i.e. a temporary variable is set up within HASH which has assigned to it as initial values the observed values of the variable.
7. The estimates of PF' and P160X1' are as follows :

$\alpha0 = .17500$	(28.425)	$\bar{R}^2 = .990$
$\alpha1 = -.00426$	(1.240)	F = 430.290
$\alpha2 = -.00282$	(4.370)	SE= .00429
$\alpha3 = .00015$	(6.419)	dW= 1.467
		n= 14
$\alpha4 = 50.93555$	(2.342)	$\bar{R}^2 = .613$
$\alpha5 = 28.56462$	(4.295)	F = 11.776
$\alpha6 = -1.60369$	(3.708)	SE= 23.3380
		dW= 1.494
		n = 14

8. Since the series for the two price variables were differently denominated, we adjusted the real producer price series in line with the percentage changes in the real world price.

9. The data was scaled down by one thousand to comply with the computational limits of the simulation package.

10. For the nonstatic runs we tabulate only those variables whose tracking performance changes from their static counterparts, and omit the individual statistics for the non-OLS runs.

11. Price and wage variables generally move in the opposite direction to 'real' variables in the multiplier results as a result of the quantity identity. Our inability to relate monetary and price variables to trade and government variables explains their lack of representation in the multiplier analysis.

12. All percentages are expressed in terms of the base value of the dependent variable.

13. The absolute magnitude of these changes depends, of course, on the strength of the shock induced, and whether it is sustained over a number of time periods. The analysis here, therefore, should be taken as a rough guide to the relative multiplier consequences of changes in the exogenous variables and not, necessarily, as indicative of any historical or potential paths for the relevant endogenous variables.

14. Note that these aggregate multipliers refer to the period 1957 to 1969 which is one year later than for the cocoa sector. This reflects data availability. Hence, the first impact on GDP comes in 1962 not in 1961. The dating of the variables is, of course, irrelevant since the multiplier repercussions are of exactly the same pattern.

15. QSC1 enters directly into the determination of RD in the monetary sector.

16. This is only proximate since the change in P160X1 is for the whole period whereas the induced change from a change in YOECD would operate with a lag.

17. The trend corrected values for $\hat{U}$ and RMSE of .8035 and 26.2135 compare with .8181 and 27.4970 for control solution 1.

CONCLUSION

The object of this thesis has been to examine the effects of export instability on post-war Ghana, by identifying the mechanism through which fluctuations were transmitted from the export to the domestic sector. This involved the construction and estimation of a macroeconomic model over the period 1956 to 1969, and the analysis of its dynamic properties by means of simulation. It is hoped that this will provide both the basis of an alternative methodology to the one currently in use, and a detailed investigation of one particular economy. It is with these twin objectives in mind that we draw together, in this final section, our concluding remarks.

Our review of the literature in Chapter 1 suggested that the early debate on the consequences of export instability tended to exhibit a lack of theoretical clarity, so that the 'pessimistic' case emerged as a rather unsatisfactory synthesis of a cycle theory, a traditional market model, and a 'structuralist' protest. The first was subsequently neglected, the second imparted an unnecessarily static bias to research; and the third remained an offshoot of a more general debate and was never adequately formulated, particularly the precise link between the short and the long-run consequences of export fluctuations.

Scepticism of the pessimistic case had led to the healthy formulation of alternative hypotheses - notably by Alasdair MacBean. This, in our view, served to force the debate into a more empirical mould, but MacBean's essentially negative findings exerted an unwarranted impact on the textbook interpretation of the problem, and subsequent research was hindered by three sources of confusion. Firstly, the adoption of a static, highly aggregative cross-section and crude multiplier analysis, lacked the degree of sensitivity required for the problem and is fundamentally in conflict with the conception of the transmission mechanism as a dynamic process. This is not to deny the usefulness of these methods in general, but to suggest that the empirical results have not been very consistent and that a change of course might be useful. Secondly, there had been a failure to clearly specify the TM implicitly assumed and to relate it to testable structural and behavioural hypotheses grounded in economic theory. Finally, the testing of the null hypothesis that instability matters, had been delayed by the absence of an explicit theory of uncertainty, and a clear specification of the costs of adjustment resulting from export fluctuations.

We have attempted in this thesis to switch the focus of analysis to a time-series simulation basis, to demonstrate how the consequences of export instability depend critically on the structural characteristics of an economy and the assumptions made about behaviour under uncertainty. By formulating the problem as one of a dynamic transmission mechanism, we hope to emphasise the interdependence between sectors of an economy, and the importance of specifying how key 'actors' adjust to fluctuations.

We shall illustrate the applications of this approach, in the light of our research on Ghana, by demonstrating how it overcomes some of the pitfalls raised in our review of the literature. We shall then summarise our major findings on Ghana.

1. Since each economy is, to some extent, structurally unique, thinking in terms of a TM forces the researcher to identify the essential features of the economy he is studying, and to compare them with those of other economies. Ghana, for example, was characterised by heavy dependence for foreign exchange and government revenue on a single primary export - cocoa ; a small but rapidly growing import substituting sector with negligible direct input-output linkages with cocoa or agriculture, but indirect dependence on imports of capital goods and raw materials; and a government committed to rapid, centrally planned, industrialisation. To this extent we felt it necessary to provide a detailed micro model of the cocoa market and emphasise in the construction of the macroeconomy the links between the cocoa subsector and income and employment through the foreign exchange market and budget variables.

2. The costs we attach to export fluctuations hinge on the reactions of transactors to variables which are undergoing change. One of the more disturbing conclusions from our research is the range of possible hypotheses about adjustment behaviour consistent with any economic model. Even if we leave aside for the moment the question of uncertainty, if we are to provide an accurate explanation of, for example, consumer behaviour, then this would necessitate a full testing of

all the alternative theories of the consumption function. Some may be ruled out a priori, but this still leaves considerable room for experimentation. The problem of export instability then becomes a subsidiary part of the wider problem of constructing and validating macroeconomic theory. The pieces of our model will always therefore be prone to revision, and the best we can expect at any moment in time is to hope that it captures the adjustment process sufficiently for us to have confidence in the conclusions we draw from it.

In our modelling of Ghana we called upon some well-documented adjustment processes for investment, employment etc., but in other cases traditional theory was either inappropriate or was no guide at all. For example, the conventional role of imports as a leakage and hence 'automatic stabiliser' in the circular flow of income, understates the positive part that imports of 'essential' capital goods can play in investment and growth. Similarly, our discussion of the government relied on a trial-and-error process of endogenising revenue and spending functions with respect to trade variables. In the absence of sectoral data on consumption we were also forced to rely on a more intuitive and casual empirical judgement as to the implications of export instability for income distribution. The reference to economic theory is not, therefore, always a panacea for the problem, but it at least forces the investigator to clearly specify how the behavioural relations in his view of the TM relate to current economic theory.

3. One of the problems of the cross-section methodology is that it is in danger of missing the subtlety of the TM by 'aggregating' the problem away. This is well illustrated in the case of Ghana. In Chapter 2 we discussed the paradox, that Ghana's reputation as a classic export dependent economy specialising on a primary product noted for its price instability, did not square with its low ranking in terms of export revenue instability from cross-section studies. This was ironically explained by her monopoly power over cocoa prices. One could not, however, conclude that export instability was not a problem for Ghana until one had examined the linkages between the export sector and the rest of the economy. This was particularly important in Ghana's case since a marketing board drove a wedge between the world cocoa price and the price paid to farmers. The strength of the TM depended on a fairly detailed analysis of the farmer's ability to shift the burden of fluctuations facing him on to other transactors and on the relative magnitude of instability in the export-based components of government revenue.

4. A major force behind the argument that export instability constitutes a serious problem for many LDCS, relates to

the question of behaviour under uncertainty. Since this is itself a complex and rapidly changing area, it is all the more incumbent upon the researcher to carefully demarcate the particular theory of uncertainty which underpins his discussion of the TM. In Chapter 1 we utilised an input-output framework to express what the expected utility and mean-variance theories of uncertainty had to say about the general problem of export instability. This also enabled us, at the outset, to clearly state the assumptions and limitations of the theories we were to apply in subsequent chapters. We also suggested that this framework might help to pinpoint the sources of uncertainty within the TM and serve as a vehicle for the discussion of the welfare implications of diversification. In Chapter 2 we applied this theory to the cocoa farmer and derived an empirical cocoa supply function under uncertainty. It was in the testing of this function that the conclusion emerged that a large amount of empirical work may be required before we can say anything concrete about this particular aspect of the export instability problem. Even if we can isolate the variables relevant to the transactor's decision (i.e. price, income, costs etc.), the direction and speed of the adjustment process, and therefore the nature and magnitude of the costs involved, depends on the identification of the type of signal to which he is responding. Even if the analysis is constrained to the first two moments of a probability distribution, the choice of forecasting model available is quite considerable, and the theory offers little guidance on the matter. If our multipliers are to reflect uncertainty adjustment (as opposed to mere technical and institutional inertia), then more will have to be done to narrow down these possibilities.

5. The adoption of a simulation technique enabled us to overcome some of the statistical deficiencies raised in Chapter 1. The cross-section methodology inevitably condenses all the information contained in a time-series into a single statistical measure of deviation from some norm or trend. If countries display different trends, or no trend at all, then distortions will be introduced. With simulation, however, we can use the actual time-series in a control solution and compare the outcomes with alternative 'stability' regimes. In our experiments with Ghana we found that a 'smoother' series per se did not necessarily result in net gains in export earnings or aggregate income. The type of stability regime is important. Simulation was also a convenient tool for assessing our econometric model and the likely errors contained within it. This is important since dynamic multipliers can only realistically represent the impact of fluctuations if the model adequately captures the structural features of the economy and the behavioural equations indicate the 'true' responses of the various 'actors' in the system. One particular dilemma which emerges from the use of simulation in the context of export instability is the liklihood that a realistic modelling of the TM (essential if the multipliers are to mean anything at all) will be

accompanied by large forecasting errors. This is inherent in the nature of model-building at this level of aggregation and it is difficult to know how to overcome this, given the current state of the 'science', without negating the basic perspective of the TM.

The conclusions we shall draw about the consequences of export instability for post-war Ghana should be viewed within the context of Ghanaian economic history as a whole. It was a period of rapid economic and socio-political change which began optimistically with independence in 1957 but had achieved few of its goals by 1969. The commitment to planned rapid industrialisation in the 1960's resulted in persistent inflation, severe under-utilisation of capacity and slow growth. Agriculture was neglected and industrial productivity was poor. The symptoms of stress were reflected in a rise in both domestic and overseas debt and a coup d'etat in 1966. The extent to which export fluctuations contributed to this picture is a matter to which we now turn.

1. On the face of it, Ghana seems to represent a classic case of a primary export-dependent economy, which is both commodity and geographically concentrated. Its major export - cocoa - is particularly susceptible to shifts in supply and demand (for inventories); and cocoa prices are volatile due essentially to price and

income inelasticity, reflecting structural inertia in supply and stable consumption patterns in DCS. Yet, as we pointed out in our methodological conclusions, because of Ghana's monopoly power over the world cocoa price, and the existence of a marketing board mechanism, the potential consequences of unstable exports are more complex than would appear at first sight. Although aggregate export earnings were relatively stable, cocoa farmer price and income were subject to greater variations, despite the Cocoa Marketing Board's limited success in smoothing out fluctuations in farmer prices. Our analysis of the options available to the farmer to shift the burden on to other transactors suggested that a major part of the adjustment was likely to have been borne by him directly. In the longer run there was an a priori possibility that farmers reacted in a risk-averse manner, and this was supported by some casual empirical evidence. However, despite some considerable experimentation with risk variables, we were unable to confirm this. We feel, however, that this may stem from the level of aggregation adopted in the cocoa subsector and from the 'roundabout' derivation of the final estimating equation for cocoa supply, resulting in loss of information embedded in the 'scrambled' coefficients. Unfortunately, absence of data on investment in cocoa precludes the separation of the planting decision from the determination of output.

2. Fluctuations originating in the cocoa subsector were then traced in chapter 3 to the macroeconomy, looking at their impact on aggregate

demand, output, employment and factor income, the government, and prices. Lack of sectoral data prevented us from testing whether consumers with highly unstable income saved more; and as we were unable to obtain significant results from a permanent income consumption function, we reverted to a simple Keynesian non-proportional relationship to obtain our estimate of the marginal propensity to consume. The change in income distribution away from cocoa farmers to food producers may have reflected the latter's relative rise in profitability and the neglect of cocoa farming by the government as a by-product of its industrialisation strategy, itself motivated in part by the risks inherent in continued dependence on a single, highly variable, cocoa crop. We linked investment to the cocoa market through an accelerator relationship based on changes in demand, but also indirectly through its dependence on 'essential' imports of inputs into the production function, themselves sensitive to foreign exchange earnings from the export sector. We found no evidence of risk aversion, and transfers abroad reinforced rather than compensated for export shortfalls, although the impact was very small in magnitude. Imports generally varied with exports, despite controls, but did not provide a strong automatic stabiliser. Fluctuations in imports of capital machines and raw materials, however, upset capacity utilization in industry and agriculture (Killick 1978); and ironically, the presence of controls may have increased the domestic multiplier impact of autonomous changes in cocoa variables.

The lack of substitution possibilities between domestic and imported inputs, together with the fairly rigid, capital-intensive nature of production in Ghanaian industry, suggested a fixed coefficient production function with an appropriate partial-adjustment mechanism. Since employment was demand determined, the burden of adjustment from fluctuations in aggregate demand fell primarily on output and employment. We did not find any evidence of systematic shifts in factor shares. We considered the government sector an important link between the cocoa subsector and the domestic economy. The government was heavily dependent on revenue from the cocoa subsector; it was playing an important part in the economy, and cocoa revenue was not a stabilizing element of total revenue. The government did not act countercyclically (except during a crisis) nor remained passive when revenue or exchange reserves varied, and we found it very difficult to endogenise its spending behaviour. Successive governments in the 1960's failed to restrict their growth policies to the constraints imposed by the budget or foreign exchange market. The adjustment was borne, not by accommodating variations in reserves, nor by expatriated profits, but by increasing foreign debt and inflation. Costs were the result of crisis adjustment. The stability of export revenue in aggregate, therefore, seriously understates the importance of export fluctuations within the context of a government committed to rapid import substituting growth and subject to a foreign exchange constraint reflecting deteriorating export performance.

Finally we looked at money and prices. The backwardness of the money market in Ghana encouraged us to adopt a modified quantity theory. Despite efforts to relate the money supply to government debt, the trade balance, and exchange reserves; we were left with a constant trend increase. As with fiscal policy, monetary policy was neither passive nor countercyclical in the 1960's, but was used to finance the growing government deficit. We were also unable to provide a sophisticated explanation for the price inflation over this period. The major explanation seems to lie in excessive spending in years when export earnings rose, not matched by a contraction of spending when earnings fell. In addition, there were cost-push pressures from rising food prices (exacerbated by import controls to save foreign exchange), and excess demand for import substituting goods due to supply bottlenecks. There is no evidence of cost-push pressures from the cocoa sector since, if anything, the fall in farmer disposable income over the period acted as a deflationary device.

3. In Chapter 4 we assembled the various components of the econometric model, and exposed it to simulation analysis. The cocoa market was constructed in line with the known dynamics of cocoa price behaviour. In particular it

incorporated a cobweb dimension by which current output was determined by past plantings which in turn related to past expectations about producer prices. The addition of demand and inventory equations provided a novel general equilibrium insight into the market. The final step was to specify cocoa export equations to provide the link with the macroeconomy. The control solutions for the cocoa subsector were very encouraging but some of the forecast errors for the macroeconomy and the combined model proved alarmingly high. Alternative estimation methods did little to ameliorate this. Nonstatic solutions raised no serious problems and the calculation of some stochastic multipliers increased confidence in the stability of the model.

The simulation exercises confirmed the important repercussions which the cocoa market has on the economy. A rise in the real producer price and in rest of the world output were detrimental in the long-run to Ghana's export earnings and domestic product, due to the depressing effect which the subsequent increase in output has on export price. An increase in the incomes of consuming countries, however, increased earnings and product. We then compared these multipliers with others originating in the government sector and non-cocoa international economy.

The latter had a negligible impact and, although real government consumption spending had a noticeable influence on activity, it served only to emphasise the relatively important role that the cocoa market plays in the Ghanaian economy.

Finally, we explored some counterfactuals. Replacing our series for the real producer price by a 'smoother' version and the real world price, resulted in net losses in real cocoa export earnings of about 12 million cedis from 1961 to 1969. Substituting a smoother series for real cocoa export earnings, however, raised GDP by approximately 3 million cedis per annum from 1957 to 1969. These exercises were not designed with particular government policies in mind, but only to demonstrate the use of simulation for such purposes. Whether unstable exports matters, depends on the 'costs' attached to them, which in turn necessitates normative judgements. What we have attempted to do in this thesis is not to make such judgements, but to isolate the transmission mechanism upon which such costs depend.

We hope that this thesis will provide both a methodological prototype for the further exploration of the problem of export instability, and a prototype for the detailed analysis of the Ghanaian economy.

APPENDIX I

Some selected instability measures

1. The United Nations index

The arithmetic mean of the percentage deviations based on the larger value.

$$I\text{-}I_1 = \frac{100}{n-1} \cdot \sum \frac{|x_t - x_{t-1}|}{\max(x_t,\ x_{t-1})}$$

Where x_t = The value of exports in time t

n = The number of years

i.e. absolute differences in values from year to year expressed as a percentage of the larger of the two values and averaged.

Example: The United Nations (1952).

2. The Michaely index

The arithmetic mean of the percentage deviations from the previous value.

$$I\text{-}I_2 = \frac{100}{n-1} \cdot \sum \frac{|x_t - x_{t-1}|}{x_{t-1}}$$

i.e. absolute differences in values from year to year expressed as a percentage of the previous year and averaged.

Example: Michaely (1962).

Indexes 1 and 2 are simple to compute but involve no explicit method of trend correction and can be misleading. For example, if there were steady logarithmic growth 100, 110, 121 ..., this method would indicate instability where none in fact existed. This index is therefore less applicable to export revenue series which exhibit strong trends and is more applicable to, say, price data.

3. The log variance index

$$I\text{-}I_3 = \text{antilog} \sqrt{V \log}$$

$$\text{Where } V \log = \frac{1}{n-1} \cdot \sum \left(\log \frac{x_{t+1}}{x_t} - m \right)^2$$

$$\text{and } m = \frac{1}{n-1} \cdot \sum \log \frac{x_{t+1}}{x_t}$$

Example: Coppock (1962).

This index suffers from the considerable drawback that it is strongly influenced by the choice of initial and terminal values of the series, and hence is very sensitive to the period chosen:

$$m = \frac{1}{n} \cdot \sum_{2}^{n} (\log x_t - \log x_{t-1}) = \frac{1}{n-1} \cdot (\log x_n - \log x_1)$$

See Sundrum (1967) for further discussion.

4. The moving averages index

The arithmetic mean of the percentage deviations from an Nth year moving average.

$$I\text{-}I_4 = \frac{100}{n-(N-1)} \cdot \sum \frac{|x_t - MA|}{MA}$$

Example: MacBean (1966).

Where MA = An Nth year moving average of x_t

This method has been heavily criticised in so far as the choice of moving average and weights are arbitrary but control the degree of smoothing. A regular cycle must exist in the data and be of the chosen duration. If the cycle is greater than the moving average, then the series is depressed and instability will be understated. This criticism has been levelled against MacBean's choice of a five-year moving average. See Ady (1969). There is also the danger of generating a Yale-Slutsky oscillatory series.

5. The ordinary least squares method (linear)

a) The arithmetic mean of the percentage deviations from a trend line fitted by OLS.

Example: Leith (1970).

$$I\text{-}I_{5a} = \frac{100}{n} \cdot \sum \frac{|x_t - \hat{\alpha} - \hat{\beta}t|}{\hat{\alpha} + \hat{\beta}t}$$

Where $\hat{\alpha}$ = The constant coefficient

$\hat{\beta}$ = The trend coefficient

i.e. fit: $x_t = \alpha + \beta t + e_t$ and obtain estimates of $\alpha, \beta = \hat{\alpha}, \hat{\beta}$

b) The root mean of the squared deviations from a trend line fitted by OLS expressed as a percentage of the mean of the observations.

$$I\text{-}I_{5b} = \frac{100}{n} \cdot \sqrt{\sum \frac{(e_t)^2}{\bar{x}}}$$

Where $\bar{x} = \sum \frac{x_t}{n}$

i.e. the normalised standard error of the estimate. A pure number measure of the variation of the series as a whole.

Example: Massell (1964).

c) The arithmetic mean of the absolute values of the yearly changes from a trend line fitted by OLS expressed as a percentage of the mean of the observations.

$$\text{I-I}_{5c} = \frac{100}{n} . \sum \frac{|x_t - x_{t-1} - \hat{\beta}|}{\bar{x}}$$

This index is reversible with regard to time, symmetric with regard to a common trend; multiplicative i.e. allows for the relative importance of variation; and is independent of the size of the trend.

Example: Glezakos (1972).

d) The arithmetic mean of the rate of change of exports from a trend fitted by OLS and expressed as a percentage of the larger value.

$$\text{I-I}_{5d} = \frac{100}{n} . \sum \frac{|e_{t+1} - e_t|}{\max(x_t, x_{t+1})}$$

i.e. a pure number measure of the year to year changes.

Example: Massell (1964).

6. Ordinary least squares (exponential)

a) The root mean of the squared deviations from an exponential trend line fitted by OLS.

i.e. the trend in x_t is given by a constant rate of growth:

$$\hat{x} = \alpha(1+r)^t = \alpha\beta^t$$

$$\text{I-I}_{6a} = \frac{100}{n} . \sqrt{\sum(e_t)^2}$$

Where $e_t = \log x_t - \hat{\alpha}\hat{\beta}^t$

i.e. fit the equation $\log x_t = \alpha + \beta t + e_t$; obtain estimates $\hat{\alpha}$, $\hat{\beta}$ by taking antilogs of the regression coefficients, or plot on semi-log paper.

It is the exponential equivalent of the standard error of the estimate.

Example: Lawson (1974).

b) The arithmetic mean of the percentage deviations from an exponential trend line fitted by OLS.

$$I\text{-}I_{6b} = \frac{100}{n} \cdot \sum \frac{|x_t - \hat{x}_t|}{\hat{x}}$$

Example: Kingston (1976).

c) The root mean of the squared deviations from an exponential trend line fitted by OLS and expressed as a percentage of the mean of the observations.

$$I\text{-}I_{6c} = \frac{100}{n} \cdot \sqrt{\sum \frac{e_t^2}{\bar{x}}}$$

i.e. the exponential equivalent of the normalised standard error of the estimate.

Example: Kingston (1976).

The OLS method has been the most popular in the literature, although it will produce a rigid trend unless the Y values are random and normally distributed and the X values are fixed. Hence it is not very useful if the period is split into a number of sub-periods with markedly different rates of growth.

APPENDIX II

The supply function under uncertainty

The problem is to maximise:

$$(7') \qquad \Pi_o = \int F\ (K_t,\ \dot{K}_t,\ t\ )\ dt$$

by using classical calculus of variations to choose K_t such that the optimal path of the capital stock satisfies at each time-period the Euler differential equation[18]:

$$(8) \qquad \frac{d}{dt}\ \frac{\partial F}{\partial \dot{K}} = \frac{\partial F}{\partial K}$$

$$F = e^{-rt}\left[p\,\alpha K - m\,\sigma_\varepsilon^2\ \alpha^2 K^2 - a\dot{K} - b\,\dot{K}^2 - m\,p^2\,\sigma_\mu^2\right]$$

so:

$$\frac{\partial F}{\partial K} = e^{-rt}\left[p\alpha - 2\ m\ \sigma_\varepsilon^2\ \alpha^2\ K\right]$$

$$\frac{\partial F}{\partial \dot{K}} = e^{-rt}\left[-\ a\ -2\ b\ \dot{K}\right]$$

Hence:

$$\frac{d}{dt}\ \frac{\partial F}{\partial \dot{K}} = -\ re^{-rt}\left[-\ a\ -\ 2\ b\ \dot{K}\right] + e^{-rt}\left[-\ 2\ b\ \ddot{K}\right] = e^{-rt}\left[r\ a + 2\ b\ r\ \dot{K} - 2\ b\ \ddot{K}\right]$$

Putting these expressions back into (8) and setting it equal to zero yields the following first-order condition:

$$p\alpha - 2\ m\ \sigma_\varepsilon^2\ \alpha^2\ K - a\ r - 2\ b\ r\ \dot{K} + 2\ b\ \ddot{K} = 0$$

A rearrangement of this expression corresponds to the general expression for a second-order differential equation (see Chiang 1974, 502):

$$\ddot{K} + a1\,\dot{K} + a2\,K = d$$

$$\text{i.e. } \ddot{K} - r\,\dot{K} - \frac{\left[2\,m\,\alpha^2\ \sigma_\varepsilon^2\right]}{2b} K = \frac{r\,a - p\alpha}{2b}$$

$$\text{With } a1 = -r; \quad a2 = -\frac{[\,\cdot\,]}{2b}; \quad d = \frac{r\,a - p\alpha}{2b}$$

Where $[\cdot]$ represents the bracketed K terms.

The particular integral Yp is:

$$Yp = \frac{d}{a2} = \frac{ra - p\alpha}{2b} \Big/ -\frac{[\,\cdot\,]}{2b}$$

$$\text{or} \qquad \frac{p\,\alpha - r\,a}{[\cdot]}$$

and the complementary function kc is given by:

$$kc = A1\,e^{R1t} + A2\,e^{R2t}$$

Where A1 and A2 are arbitrary constants and $R1 > 0$; $R2 < 0$ are roots of the quadratic:

$$R1, R2 = \frac{-a1 \pm \sqrt{a1^2 - 4a2}}{2}$$

The general solution, therefore, is given by:

$$K_t = A1\,e^{R1t} + A2\,e^{R2t} + \frac{d}{a2}$$

Since A1 = 0 by assumption, the general solution for K* is K* = K_o - A1; so substitution into the quadratic and specification of the initial conditions, gives the solution (10) and K^*_t approaches the particular integral.

APPENDIX III

The yield pattern of an Amelonado cocoa tree

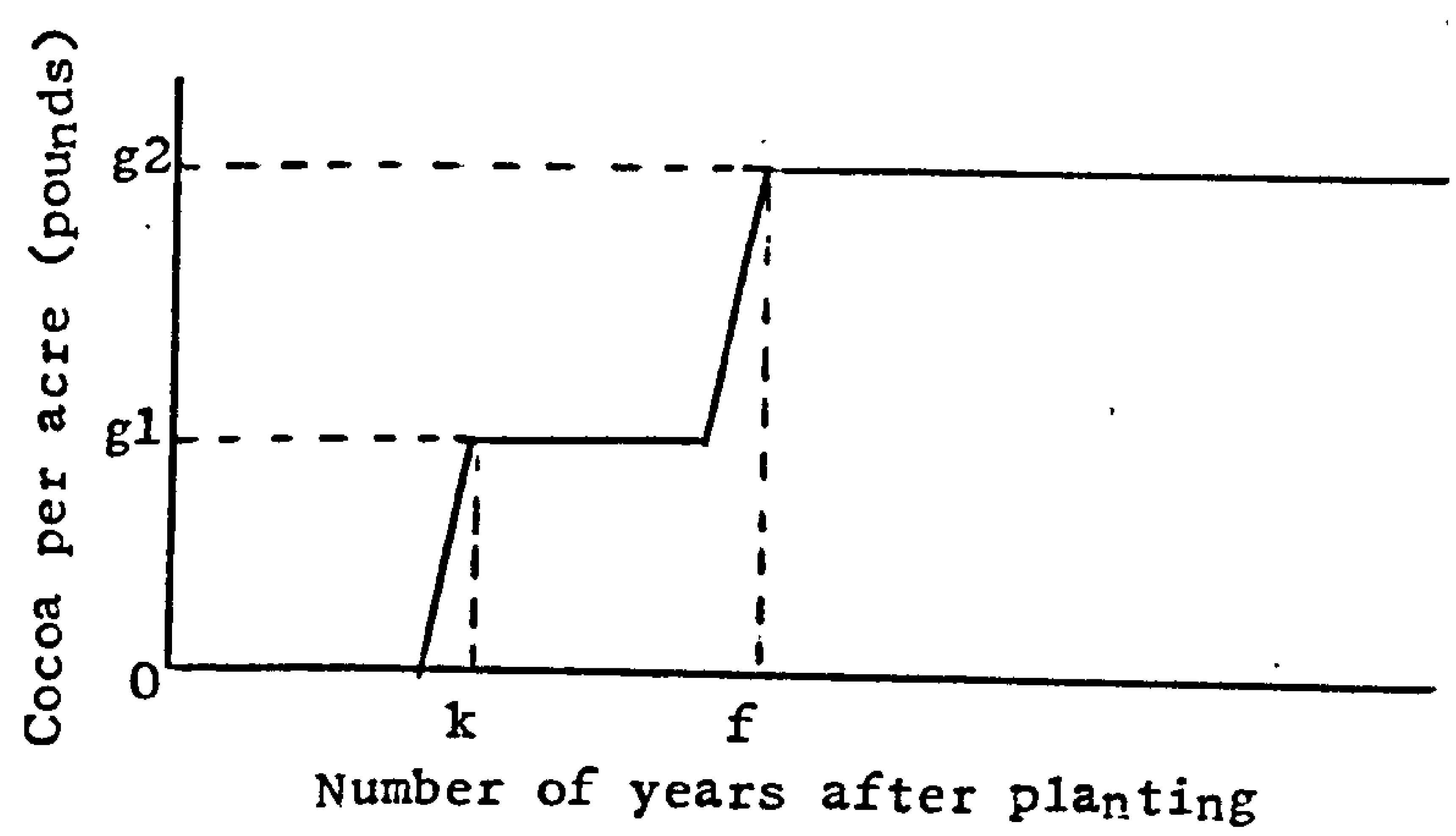


FIGURE 2.6 The yield pattern of an Amelonado cocoa tree

FIGURE 2.6 represents the life-cycle of a typical cocoa tree from planting to maturity, from Bateman (1965). From 0 to k (approximately five years) there is a gestation period in which output is zero. In the following year output per tree and per acre increase significantly. After this initial increase, yield per tree and per acre level off for three or four years, followed by another rapid increase after f years. After this second period of growth, output per tree continues to increase to an advanced age, for as long as forty years after planting. On the other hand, the yield per acre increases at a slow pace for about five years and then levels off. Peak production is then maintained for another fifteen to twenty years, at which time yield per acre begins to fall as trees become casualties at a rate more than offsetting the increase in yield per tree.

The yield function used in the text represents a linear approximation of the cycle depicted above. g1 represents the yield after the first plateau is reached and output per acre remains fairly constant until the second plateau at f approximated by g2. The assumption that peak yields are maintained for an infinite time is palatable to the extent that trees retain an economic life until about forty years and (in the absence of disease etc.) regenerate at intervals.

APPENDIX IV

Variables used in the econometric model

The following abbreviations are used when defining the variables which appear in the econometric model :

NC = New cedis
MT = Metric tons
GD = Gill and Duffus Ltd. (1972)
SYG= Statistical Yearbook of Ghana. Central Bureau of Statistics (1955-1970a)
TMB= Merritt-Brown (1972)
LE = Leith (1974)
QDS= Quarterly Digest of Statistics. Central Burèau of Statistics (1955-1970b)

B	The number of banks in Ghana. SYG.
C	Total private consumption spending, 1960=100,NC (000). TMB. C-2.
CONSTANT	A constant for regression.
CM	The ratio of cash to money stock, NC (000), annual averages. TMB H-3.
CSM	Capital services imported, NC (000). TMB F-5.
CSP	Net private short-term capital flows, NC (000). TMB G-1.
CSX	Capital services exported, NC (000). TMB F-5.
D	A dummy variable with the value of unity for the years specified.
D1,D2,D3,	Dummy variables used in the export tax equation assuming the value of unity for those years in which the conditions of the schedule were satisfied.
E1	Employment in business and government business, persons (000). TMB B-2.
E2	Employment in government administration and the military, persons (000). TMB B-2.
G	Total current government spending, NC (000). TMB E-4.
GA	Government consumption spending and interest on the National Debt, NC (000). TMB E-4.

GC60	Government consumption spending, 1960=100, NC (000). TMB C-1 (revised).
GDP	Gross domestic product, 1960=100, NC (000). TMB C-2 (revised).
GYD	Government disposable income, NC (000). TMB E-5.
H	The supply of high powered money, NC (000), annual averages. TMB H-1.
I1R1	Net investment in construction and building, 1960=100, NC (000). TMB D-1.
I2R2	Net investment in transport, machinery and equipment, 1960=100, NC (000). TMB D-1.
I3	Inventory spending, 1960=100, NC (000).
I3NOML	Inventory spending, NC (000).
K1	The mid-year capital stock for building and construction, 1960=100, NC (000). TMB D-1.
K2	The mid-year capital stock for transport, machinery and equipment, 1960=100, NC (000). TMB D-1.
KM	The money supply multiplier.
L	The labour supply, persons (000). TMB A-3.
LN	Natural logarithms.
LSX	Net labour services exported, NC (000). TMB C-1.
M	Total imports of goods and non-factor services, NC (000). TMB C-1.
MO	Imports of food and live animals, 1960=100, NC (000). SYG and LE.
M1	Imports of beverages and tobacco, 1960=100, NC (000). SYG and LE.
M24	Imports of crude materials (excluding fuels) and imports of animal and vegetable oils and fats, 1960=100, NC (000). SYG and LE.
M3	Imports of mineral fuels, lubricants and related minerals, 1960=100, NC (000). SYG and LE.
M5	Imports of chemicals, 1960=100, NC (000). SYG and LE.
M6	Imports of manufactured goods, 1960=100, NC (000). SYG and LE.

M68	M6 + M8.
M7	Imports of machinery, transport and equipment, 1960=100, NC (000). TMB D-1.
M8	Imports of miscellaneous manufactured articles, 1960=100, NC (000). SYG and LE.
M9	Imports of commodities and transactions not classified per kind of transaction, 1960=100, NC (000). SYG and LE.
M1060	Imports of nonvisibles, 1960=100, NC (000). (See APPENDIX V).
MS	The total money supply, NC (000), annual averages. TMB H-3.
N	The total population, persons (000). TMB A-1.
NDP	Net domestic product, 1960=100, NC (000). TMB C-2 and D-1.
NNP	Net national product, 1960=100, NC (000). TMB C-2 and D-1.
NNP1	Net national product excluding government administration and the military, 1960=100, NC (000). TMB F-1.
NTI	Net transfers to the international sector, NC (000). TMB F-5.
P	The implicit price deflator for PCWPUS, 1960=100.
P1	The unit value of cocoa exports, NC per ton. SYG.
P160	The 1960 price of cocoa exports, NC per ton. SYG.
P160X1	The value of cocoa exports, 1960=100, NC (000).
P2	The price index for building and construction investment, 1960=100. SYG.
P3	The price index for transport, machinery and equipment, 1960=100. TMB C-3.
P4	The price index for government consumption, 1960=100. TMB C-3.
P6	The price index for locally produced food, 1960=100. SYG.
PC	The implicit price deflator for total private consumption spending, 1960=100. TMB E-3.
PCW	The average annual spot price of New York Ghana Accra cocoa converted from crop to calendar year, cents per pound. GD.

PCWPUS	PCW deflated by PUS, 1960=100.
PD	Interest payments on the National Debt, NC (000). TMB E-4.
PF	The real producer price of cocoa, £ per ton, 1960=100. Bateman (1970).
PGDP	The implicit price deflator for gross domestic product, 1960=100. TMB C-3.
PGDPGDP	Gross domestic product, NC (000). TMB C-2 (revised).
PMO	The price index CIF for imports section O, 1960=100. QDS.
PM1	The price index CIF for imports section 1, 1960=100. QDS.
PM3	The price index CIF for imports section 4, 1960=100. QDS.
PM5	The price index CIF for imports section 5, 1960=100. QDS.
PM6	The price index CIF for imports section 6, 1960=100. QDS.
PM7	The price index CIF for imports section 7, 1960=100. QDS.
PM8	The price index CIF for imports section 8, 1960=100. QDS.
PM10	The price index CIF for nonvisible imports, 1960=100. QDS.
PNDP	The implicit price index for net domestic product, 1960=100. TMB C-3.
PNDPNDP	Net domestic product, NC (000). TMB C-2 and D-1.
PUS	The United States wholesale price index, 1960=100. United States Department of Labor Bureau of Statistics (1971).
PX	The implicit price index for exports of goods and nonfactor services, 1960=100. TMB C-3.
QDC	Grindings of cocoa, MT (000), converted from crop to calendar year. GD.
QSC	Gross world output of cocoa adjusted for weight loss, MT (000), converted from crop to calendar year. GD.
QSC1	Gross output of cocoa beans in Ghana, MT (000), converted from crop to calendar year. GD.

QSC2	Gross non-Ghanaian output of cocoa adjusted for weight loss, MT (000), converted from crop to calendar year. GD.
R1	Depreciation expenditures for building and construction investment, 1960=100, NC (000). TMB D-1.
R2	Depreciation expenditures for transport, machinery and equipment investment, 1960=100, NC (000). TMB D-1.
R3	Depreciation expenditures for government investment, 1960=100, NC (000). TMB D-1.
R3NOML	Depreciation expenditures for government investment, NC (000). TMB D-1.
RD	The commercial banks' reserves ratio to total deposits, NC (000), annual averages. TMB H-3.
S	The government current surplus, NC (000). TMB E-6.
S1	Government sales of goods and services to wage and salary earners, NC (000). TMB F-2.
S2	Sales of goods and services to property and enterprise, NC (000). TMB E-2.
SC	End of year stocks of cocoa, MT (000), converted from crop to calendar year. GD.
SUB	Government subsidies, NC (000). TMB E-4.
T	A time trend.
TO	An index of indirect taxes on imports section 0, 1960=100. LE.
T5	An index of indirect taxes on imports section 5, 1960=100. LE.
T7	An index of indirect taxes on imports section 7, 1960=100. LE.
TI	Total government taxes on production and consumption, NC (000). TMB E-2.
TI1	Purchase taxes, sales taxes, local duties and taxes, fines, fees, licences, grants and miscellaneous taxes less refunds, NC (000). TMB E-2.
TIME	A time trend.
TM	Import duties and purchase and excise taxes on imports, NC (000). TMB E-2.
TR	Total government revenue, NC (000). TMB E-2.
TR1	Total government transfers to households, NC (000). TMB E-4.

TR2	Total government transfers to public corporations and institutions, NC (000). TMB E-4.
TR3	Total government transfers abroad, NC (000). TMB E-4.
TX1	Cocoa export duties, NC (000). TMB E-2.
TX2	Other export duties, NC (000). TMB E-2.
TY	Total government taxes on income, NC (000). TMB E-2.
TY1	Personal income taxes on wage and salary income, NC (000). TMB E-2.
TY2	Taxes on property and enterprise income, corporate taxes and interest, profit, dividends and rent of government institutions, NC (000). TMB E-2.
TY3	Mineral duty, NC (000). TMB E-2.
U	Unemployment, persons (000). TMB B-1.
UR	The unemployment rate (%). TMB B-1.
V	The income velocity of circulation, NC (000), annual averages. TMB H-1.
V1	The optimal capital to output ratio for building and construction investment, 1960=100. TMB D-1 and F-1.
V2	The optimal capital to output ratio for transport, machinery and equipment, 1960=100, NC (000). TMB D-1 and F-1.
VC	Voluntary contributions of cocoa farmers, NC (000). TMB E-6.
VEH	The number of licenced vehicles in Ghana. SYG.
W	The average annual wage per haed in business and government business. TMB B-1 and B-2.
W1	Wages and salaries of business and government business employees, NC (000). TMB F-1.
W2	Wages and salaries of government administration and the military, NC (000). TMB F-1.
X	Exports of goods and non-factor services, 1960=100, NC (000). TMB C-1.
X1	Net exports of raw cocoa from Ghana, MT (000). GD.
X2	Non-cocoa exports of goods and non-factor services, 1960=100, NC (000).

Y1	Income of property and enterprise, NC (000). TMB F-1.
YD	Real disposable income, 1960=100, NC (000). TMB F-4.
YD1	Disposable income of wage and salary earners, NC (000). TMB F-4.
YDPE	Disposable income of property and enterprise, NC (000). TMB F-4.
YOECD	A weighted average of real per capita national incomes of the major OECD countries. International Monetary Fund (1961-1972), United Nations (1959-1969), and United Nations (1960-1970).

APPENDIX V.

Computations for the import equations

The values for imports by SITC categories were converted into constant terms by deflating them by their appropriate Cif price indices. Nonvisibles were obtained as the difference between total imports and the sum of the SITC visible items. The general form of the relative price variables is the Cif price index for the particular commodity group multiplied by the effective tax rate and deflated by a relative price index for a domestic substitute or competing import. Price indices for SITC groups 2, 4 and 9 were unavailable so 6 was used for the composite 24 category and 8 for the 9 category. Effective tax rates were based upon import tax rates (T) from Leith (1974) and they included the ratio of the sum of import duties, sales taxes, purchase taxes, and surcharges to total imports:

$$T_i = \frac{1 + T_t}{1 + T_{1960}}$$

where i refers to the typical import category.

APPENDIX VI

OLS estimates of the econometric model of Ghana

Below are listed the equations derived in Chapters 2 and 3 as part of the macroeconomic model of Ghana, estimated by OLS. Beneath each parameter is its corresponding estimated coefficient and 't' ratio. $\bar{R}^2$ is the coefficient of multiple correlation adjusted for degrees of freedom; F is the F distribution statistic; SE is the standard error of the regression; dW is the Durbin-Watson d statistic; and n refers to the number of observations.

[23]	a_{11}	a_{12}	a_{13}	a_{14}	$\bar{R}^2$	.550
	-.28392	2.80670	-.71098	.01791	F	6.302
	(2.783)	(3.744)	(3.459)	(2.953)	SE	.03047
					dW	1.863
					n	14

[37]	a_{21}	a_{22}	a_{23}	a_{24}	$\bar{R}^2$	.902
	-.49663	1.62532	2.57099	.03630	F	40.753
	(4.725)	(2.151)	(3.915)	(6.586)	SE	.02757
					dW	2.102
					n	14

[25]	a_{31}	a_{32}	a_{33}	$\bar{R}^2$	.974
	.61396	-.00542	51.25556	F	247.310
	(10.679)	(3.896)	(20.577)	SE	.03435
				dW	1.829
				n	14

[30]	a_{41}	a_{42}	$\bar{R}^2$	.953
	53.77578	-63.99885	F	267.070
	(33.697)	(16.342)	SE	1.5130
			dW	1.891
			n	14

[31]	a_{51}	a_{52}	a_{53}	$\bar{R}^2$	.864
	.73626	-.01360	-.88384	F	28.592
	(9.174)	(8.907)	(8.569)	SE	.02386
				dW	1.506
				n	14

[32]	a_{61}	$\bar{R}^2$	.854
	14.48268	F	-
	(36.250)	SE	.04451
		dW	2.219
		n	14

[33]	a_{71}	a_{72}			$\bar{R}^2$	.861
	.92965	-.08101			F	81.782
	(38.759)	(2.351)			SE	.03226
					dW	1.500
					n	14
[1]	a_{81}	a_{82}			$\bar{R}^2$	.734
	214.18520	.61173			F	34.043
	(2.531)	(5.835)			SE	29.2750
					dW	1.577
					n	13
[3']	a_{91}	a_{92}			$\bar{R}^2$	.968
	978.43940	-.97684			F	363.740
	(33.563)	(30.873)			SE	5.66920
					dW	2.061
					n	13
[4]	a_{101}	a_{102}	a_{103}	a_{104}	$\bar{R}^2$	.891
	569.43530	-.29345	.86759	3.81510	F	33.768
	(2.725)	(9.508)	(4.329)	(4.376)	SE	5.45430
					dW	1.849
					n	13
[6]	a_{111}				$\bar{R}^2$	.966
	.13046				F	-
	(75.740)				SE	19.71077
					dW	.027
					n	13
[7]	a_{121}	a_{122}	a_{123}		$\bar{R}^2$	.605
	-31.96026	.07986	-183.32810		F	10.187
	(1.903)	(4.349)	(3.969)		SE	4.52550
					dW	1.656
					n	13
[8]	a_{131}	a_{132}	a_{133}		$\bar{R}^2$	.704
	2.78020	1.37302	-1.32769		F	15.252
	(4.936)	(4.184)	(2.727)		SE	1.49160
					dW	2.098
					n	13
[9]	a_{141}	a_{142}			$\bar{R}^2$	.577
	-12.56528	46.23118			F	18.710
	(3.073)	(4.325)			SE	2.55310
					dW	.552
					n	14

[10]

a_{151}	a_{152}		
.31189	-3.21673	$\bar{R}^2$	.759
(32.861)	(3.787)	F	41.991
		SE	1.41420
		dW	2.685
		n	14

[11]

a_{161}	a_{162}		
.05948	-2757.55600	$\bar{R}^2$	.701
(9.419)	(4.905)	F	15.071
		SE	7.07450
		dW	.956
		n	13

[12]

a_{171}	a_{172}		
1.13956	.11844	$\bar{R}^2$	.670
(3.587)	(24.319)	F	25.323
		SE	16.3470
		dW	1.573
		n	13

[13]

a_{181}	a_{182}	a_{183}	a_{184}		
-65.45855	.16977	.12871	-20.09606	$\bar{R}^2$	.853
(3.291)	(2.291)	(3.887)	(3.015)	F	24.176
				SE	6.14080
				dW	2.024
				n	13

[17]

a_{191}	a_{192}	a_{193}	a_{194}	a_{195}		
-9.68143	-.02645	.33357	1.67144	.01372	$\bar{R}^2$	.976
(.450)	(.350)	(2.060)	(.630)	(.480)	F	100.170
					SE	.00002
					dW	2.360
					n	13
a_{196}						
-.04156						
(1.790)						

[21]

a_{201}	a_{202}	a_{203}	a_{204}	a_{205}		
-2.24456	.30774	.00371	.75032	-.04580	$\bar{R}^2$	.979
(1.980)	(2.260)	(2.330)	(6.930)	(5.260)	F	140.606
					SE	.00002
					dW	2.332
					n	13

[22]

a_{211}	a_{212}	a_{213}		
.00096	.00930	.67267	$\bar{R}^2$	.963
(2.588)	(2.285)	(5.190)	F	155.520
			SE	.05520
			dW	1.213
			n	13

[23]

a_{221}	a_{222}	a_{223}	a_{224}		
.10313	.00147	.03045	.03752	$\bar{R}^2$	.983
(10.363)	(17.720)	(3.920)	(4.575)	F	235.370
				SE	.00883
				dW	2.293
				n	13

[27]

a_{231}	a_{232}	a_{233}
1060.22700	481.35420	277.71310
(12.730)	(6.550)	(5.946)

$\bar{R}^2$	.764
F	22.093
SE	10.4590
dW	1.530
n	14

[28]

a_{241}	a_{242}	a_{243}
174.63380	16.73066	41.84402
(15.479)	(2.486)	(3.761)

$\bar{R}^2$	.767
F	22.355
SE	10.23550
dW	1.183
n	14

[29]

a_{251}	a_{252}	a_{253}
.74291	640.92960	-.38659
(12.401)	(8.140)	(3.557)

$\bar{R}^2$	.835
F	33.800
SE	.13568
dW	1.333
n	14

[30]

a_{261}	a_{262}
-9.68880	.37861
(2.799)	(8.147)

$\bar{R}^2$	.834
F	66.372
SE	3.83710
dW	1.826
n	14

[31]

a_{271}	a_{272}	a_{273}
.21078	26.48045	-15.03455
(16.807)	(6.676)	(2.418)

$\bar{R}^2$	.819
F	20.577
SE	5.5280
dW	2.219
n	14

[32]

a_{281}	a_{282}
-38.90586	.06419
(4.911)	(11.337)

$\bar{R}^2$	.914
F	128.520
SE	9.04880
dW	1.047
n	13

[33]

a_{291}	a_{292}
.01429	-10.89527
(20.976)	(6.885)

$\bar{R}^2$	.704
F	29.472
SE	2.06970
dW	2.048
n	13

[34]

a_{301}	a_{302}	a_{303}
-48.18248	.09602	397.54950
(3.139)	(13.764)	(2.965)

$\bar{R}^2$	.969
F	185.450
SE	8.580
dW	2.0
n	13

[35]

a_{311}	a_{312}	a_{313}	a_{314}
-19.28405	3.77319	13.88869	.08391
(6.295)	(8.842)	(8.467)	(4.225)

$\bar{R}^2$	.966
F	123.790
SE	1.36990
dW	1.233
n	14

[41]

a_{321}	a_{322}		
39.40220	8.42066	$\bar{R}^2$	.917
(6.622)	(12.051)	F	145.220
		SE	10.540
		dW	1.036
		n	14

[42]

a_{331}	a_{332}	a_{333}		
3.71250	-3.20442	-2.18518	$\bar{R}^2$	.978
(52.723)	(23.415)	(10.945)	F	285.710
			SE	.03584
			dW	1.661
			n	14

[43]

a_{341}	a_{342}	a_{343}		
.64201	-12.33620	-.06484	$\bar{R}^2$	.941
(26.195)	(9.181)	(4.609)	F	105.250
			SE	.01827
			dW	1.816
			n	14

[44]

a_{351}	a_{352}	a_{353}	a_{354}		
.21132	-.43784	.00008	.09697	$\bar{R}^2$	.923
(9.564)	(7.216)	(7.804)	(5.883)	F	37.060
				SE	.01476
				dW	2.051
				n	13

a_{355}
-.03822
(2.400)

[45]

a_{361}	a_{362}		
8.20722	-123.33400	$\bar{R}^2$	.636
(16.651)	(4.867)	F	23.690
		SE	.40741
		dW	.785
		n	14

[46]

a_{371}	a_{372}	a_{373}		
.02254	.50900	.01474	$\bar{R}^2$	.992
(6.760)	(35.810)	(3.600)	F	753.510
			SE	.00376
			dW	1.90
			n	13

[47]

a_{381}	a_{382}		
.07852	.87620	$\bar{R}^2$	.927
(2.603)	(13.008)	F	152.350
		SE	.00545
		dW	2.348
		n	13

[48]

a_{391}	a_{392}		
.05175	4.88425	$\bar{R}^2$	.947
(12.355)	(15.306)	F	234.270
		SE	.00572
		dW	2.188
		n	14

APPENDIX VII

Non-OLS estimates of the econometric model of Ghana

2SLS

Eq.					
[25]	a_{31}	a_{32}	a_{33}	$\bar{R}^2$	.974
	.61256	-.00538	51.27128	F	247.290
	(10.628)	(3.852)	(20.579)	SE	.03440
				dW	1.213
				n	14
[33]	a_{71}	a_{72}		$\bar{R}^2$	.861
	.92929	-.08083		F	81.777
	(38.729)	(2.345)		SE	.03266
				dW	1.501
				n	14

LIVE

Eq.					
[25]	a_{31}	a_{32}	a_{33}	$\bar{R}^2$	.990
	.64576	-.00654	51.12703	F	711.330
	(19.303)	(7.952)	(34.917)	SE	.02040
				dW	1.036
				n	14
[33]	a_{71}	a_{72}		$\bar{R}^2$	.776
	.92174	-.04845		F	46.055
	(30.769)	(1.128)		SE	.04055
				dW	1.498
				n	14
[1]	a_{81}	a_{82}		$\bar{R}^2$	.233
	451.32880	.31945		F	4.645
	(3.80)	(2.155)		SE	49.6730
				dW	.962
				n	13
[3']	a_{91}	a_{92}		$\bar{R}^2$	.719
	917.33060	-.14895		F	16.365
	(5.571)	(5.481)		SE	16.0590
				dW	1.650
				n	13

[4]	a_{101}	a_{102}	a_{103}	a_{104}	$\bar{R}^2$	.611
	746.09370	-.25540	.38716	5.52152	F	7.281
	(1.090)	(4.429)	(.579)	(3.117)	SE	10.3150
					dW	1.262
					n	13
[7]	a_{121}	a_{122}	a_{123}		$\bar{R}^2$	.491
	-28.13338	.07625	-218.05580		F	6.783
	(1.434)	(3.526)	(3.487)		SE	5.1380
					dW	1.657
					n	13
[11]	a_{161}	a_{162}			$\bar{R}^2$	.481
	.05848	-26592.770			F	6.569
	(6.750)	(3.472)			SE	9.4260
					dW	.848
					n	13
[12]	a_{171}	a_{172}			$\bar{R}^2$	.778
	1.12255	.11686			F	43.127
	(4.286)	(29.602)			SE	13.470
					dW	1.894
					n	13
[13]	a_{181}	a_{182}	a_{183}	a_{184}	$\bar{R}^2$	.656
	-21.58103	.25575	.05837	-21.27660	F	8.611
	(.808)	(1.910)	(1.140)	(2.063)	SE	9.3950
					dW	1.067
					n	13
[22]	a_{211}	a_{212}	a_{213}		$\bar{R}^2$	.935
	-.00013	-.00587	1.05339		F	87.825
	(.349)	(1.005)	(7.716)		SE	.07090
					dW	1.028
					n	13
[23]	a_{221}	a_{222}	a_{223}	a_{224}	$\bar{R}^2$	.876
	.11084	.00152	.01447	.02330	F	29.369
	(3.959)	(5.904)	(.605)	(1.075)	SE	.02398
					dW	2.170
					n	13
[28]	a_{241}	a_{242}	a_{243}		$\bar{R}^2$	.849
	181.63920	12.84030	35.94445		F	34.841
	(19.226)	(2.344)	(3.992)		SE	8.19960
					dW	1.160
					n	13

[33]	a_{291}	a_{292}		$\bar{R}^2$	.865
	.01439	-10.03867		F	77.672
	(31.248)	(9.572)		SE	1.39880
				dW	2.076
				n	13

[42]	a_{331}	a_{332}	a_{333}	$\bar{R}^2$	.800
	3.63371	-3.0680	-2.00405	F	25.036
	(16.225)	(6.888)	(2.954)	SE	.01029
				dW	1.342
				n	13

APPENDIX VIII

Simulation tracking performance for the endogenous variables of the econometric model

Control Solution 1. The cocoa subsector (including X1), static solution, 1956-1969.

	$\hat{U}$	UM	US	UC	AE	RMSE
QSC1	.8181	.0018	.0225	.9757	0.0	27.4970
QDC	.3552	.0174	.3881	.5945	.0040	9.4919
PCWPUS	.6913	0.0	.0661	.9339	-.0294	36.7772
P1	.5803	.0138	.3388	.6473	-.4169	38.1829
X1	.7003	.0044	.0465	.9492	-.2865	46.5856
P160X1	1.1613	.0143	.1785	.8072	-2.3386	54.4450
QSC	.4414	.0008	.0003	.9989	0.0	12.5858
SC	.4769	.0008	.0217	.9775	-.0101	20.3167

Control Solution 2. The cocoa subsector (excluding X1), static solution, 1956-1969.

	$\hat{U}$	UM	US	UC	AE	RMSE
QSC1	.8181	.0018	.0225	.9757	0.0	27.4970
QDC	.3552	.0174	.3881	.5945	.0040	9.4919
PCWPUS	.6913	0.0	.0661	.9339	-.0294	36.7772
P1	.5803	.0138	.3388	.6473	-.4169	38.1829
P160X1	.7112	.0125	.3872	.6003	-2.2036	35.1211
QSC	.4414	.0008	.0003	.9989	0.0	12.5858
SC	.4769	.0008	.0217	.9775	-.0101	20.3167

Control Solution 3. The Macroeconomy, static solution, 1957-1969.

	$\hat{U}$	UM	US	UC	AE	RMSE
C	1.4642	.0334	.0041	.9626	.6350	97.8292
YD	1.2239	.0281	.1759	.7961	.9129	66.9155
I1R1	1.3616	.0093	.0810	.9097	.7904	49.2543
V	.9983	.0445	.4617	.4938	.8482	52.3158
I2R2	.7175	.0060	.0907	.9034	7.0044	59.3866
M7	.6898	.0809	.0621	.8569	1.5115	58.7806
R2	.4044	.0090	.1621	.8289	.2823	18.7246
MO	.8549	.0147	.1130	.8723	-3.1290	71.8105
GDP	1.1438	.0273	.0873	.8853	-1.5496	58.0543
M1	1.0548	.0070	.4343	.5587	1.9270	61.6493
M3	1.0305	.0057	.0175	.9768	.3837	51.1939
M5	1.3024	.0138	0.0	.9862	2.7982	63.8668
PC	1.2066	.0143	.0141	.9715	.2325	34.6539
M68	.6220	0.0	.0367	.9632	-1.5866	45.8287
E1	.8944	.0575	.0032	.9393	.2193	33.5695
NNP1	1.2435	.0402	.0955	.8644	.8714	66.6045
UR	1.2417	.0429	.0026	.9545	-1.6042	77.2796
W	1.1097	.0039	.0344	.9618	.2900	33.3260
PNDP	1.3271	.0141	.0619	.9240	.4713	34.2207
TX1	.5656	.0002	.0342	.9656	-.8998	44.7920
TM	.5742	.0004	.0566	.9431	.5590	37.5474
M	.3101	.0605	.0692	.8703	.2030	32.0907
TX2	.7194	.0098	.0445	.9457	1.4126	33.4629
TY1	.9740	.0006	.3767	.6227	-.7774	40.6821
TI1	1.7688	.0782	.0976	.8242	2.8305	41.1734
NDP	1.1946	.0393	.0815	.8792	.8164	63.7614
S1	.8195	.0060	.0591	.9350	2.2194	37.7703
YD1	1.2023	.0008	.3223	.6768	1.6806	33.3934
GA	.5816	.0005	.0067	.9928	-1.1631	18.9055
PGDP	1.3646	.1280	.0601	.9270	.2887	36.3336
TR1	.6486	.0195	.2310	.7494	-.9061	18.7931
H	.8284	.0001	.4212	.5786	-1.1129	26.3915
KM	.7208	.0124	.0468	.9408	.1612	41.1110
CM	.8600	.0027	.0049	.9924	-.1114	25.0954
RD	.4451	.0677	.2478	.6845	-.8649	27.4987
MS	.7715	.0169	.0004	.9827	-1.0978	20.5218
P2	.9960	.0054	.0263	.9684	.1234	27.6044
P3	1.0458	.0004	.3382	.6614	-.1532	22.9194
PGDPGDP	.9857	.0001	.0271	.9728	-1.2259	26.4624
NNP	1.2156	.0398	.0910	.8692	.8193	65.4595
TI	.7885	.0026	.0701	.9273	.8898	34.4790
TY	.7100	0.0	.0043	.9957	1.6753	21.1157
TR	.6068	.0004	.0359	.9637	1.1295	25.6750
GYD	.5927	.0006	.0000	.9994	1.7000	49.4951
G	.4781	.0027	.0195	.9778	-.8707	12.2808
S	5.9483	.0716	.6760	.2524	14.6745	76.4333
U	1.2246	.0426	.0025	.9549	-2.5078	73.1011
PNDPNDP	.0721	.0067	.6241	.3692	.0898	1.9468
W1	.7194	.0017	.0125	.9856	.7069	22.1661
TY2	1.3944	.0507	.4192	.5301	3.6641	37.7013

Control Solution 4. The cocoa subsector and macroeconomy, static solution, 1957-1969.

	$\hat{U}$	UM	US	UC	AE	RMSE
QSC1	.7869	.0020	.0350	.9630	-.4395	28.9375
QDC	.3580	.0365	.4156	.5479	-.0319	10.2326
PCWPUS	.6365	.0441	.0150	.9409	..8005	34.8680
SC	.4573	.0197	.0584	.9219	-.2802	21.1647
P1	.5835	.0149	.3444	.6408	.1625	37.3890
X1	.8364	.0015	.0596	.9389	-.4774	49.9282
C	1.7598	.0141	.0465	.9394	.2009	105.6180
YD	1.6141	.0049	.3048	.6903	.2914	76.2250
I1R1	1.4698	.0274	.4095	.5631	-1.4720	48.6912
P160X1	1.2226	.0099	.1286	.8615	-2.2481	56.9309
V	.9983	.0445	.4617	.4938	.8482	52.3158
I2R2	1.7496	.0410	.2845	.6746	-3.7872	66.0632
M7	.7855	.0159	.0166	.9675	-.4579	66.9418
R2	.4044	.0090	.1621	.8289	.2823	18.7246
MO	.5371	.0046	.0001	.9954	-.4579	70.3485
GDP	1.5152	.0031	.2818	.7151	.2823	68.3938
M1	1.0382	.0077	.4726	.5197	.9486	56.3058
M3	1.0305	.0057	.0175	.9768	.3837	51.1939
M5	1.6092	.0216	.0373	.9410	1.8562	68.4499
PC	1.1018	.0099	.0076	.9825	.5323	33.4948
M68	.6726	0.0	.0684	.9316	-2.2744	50.4482
E1	1.2234	.0210	.0439	.9351	-.0276	39.5548
NNP1	1.6860	.0054	.3348	.6598	.0903	78.1101
UR	1.5650	.0236	.0203	.9561	1.5739	89.2594
W	1.1538	.0018	.1196	.8785	.5203	36.1534
PNDP	1.4070	.0084	.1505	.8411	.8573	36.7855
TX1	.8518	.0001	.0042	.9957	-.5358	67.8552
TM	.5384	.0020	.0035	.9944	.0766	33.9605
M	.4904	.0196	.1095	.8709	-.3529	37.9334
TX2	.7194	.0098	.0445	.9457	1.4126	33.4629
TY1	.9740	.0006	.3765	.6229	-.7766	40.6766
W1	.6608	.0047	.0232	.9721	.7502	21.8992
TY2	1.3944	.0507	.4192	.5301	3.6641	37.7013
TI1	1.6088	.0757	.0510	.8733	2.7476	40.5255
NDP	1.6210	.0054	.2883	.7062	.0500	74.7596
S1	.8758	.0069	.0707	.9224	2.1751	39.8344
YD1	1.2235	.0004	.3459	.6537	1.6424	33.5344
GA	.6091	0.0	.0001	.9998	-1.2071	20.3284
PGDP	1.4198	.0075	.1343	.8582	.6935	38.2461
TR1	.6145	.0113	.0467	.9416	- .8167	22.3943
H	.8284	.0001	.4212	.5786	-1.1129	26.3915
KM	.6363	.0094	.2388	.7519	.0907	36.6475
CM	.8600	.0027	.0049	.9924	-.1114	25.0954
RD	.5619	.0436	.2621	.6943	-.4431	32.4509
MS	.7359	.0146	.0081	.9773	-1.1289	20.4177

continued ...

Control Solution 4 continued ...

	$\hat{U}$	UM	US	UC	AE	RMSE
P2	.9753	.0042	.0275	.9682	.1814	26.5219
P3	1.0458	.0004	.3382	.6614	-.1532	22.9194
QSC	.4288	.0027	.0031	.9942	-.1443	13.3556
PGDPGDP	.9149	0.0	.0064	.9935	-1.2725	26.3309
NNP	1.6499	.0053	.3176	.6771	.0449	76.7243
TI	1.0859	.0039	.0573	.9388	.7680	43.1922
TY	.7126	0.0	.0057	.9943	1.6666	21.1974
TR	1.0391	.0022	.0716	.9262	1.0422	32.6150
GYD	.9288	.0032	.1171	.8797	1.5673	62.4300
G	.4861	.0013	0.0	.9987	-.8947	12.9903
S	1.0775	.0105	.0203	.9691	14.1704	104.8872
U	1.5443	.0236	.0203	.9561	.3157	86.1347
PNDPNDP	.0843	.0039	.4860	.5101	.0613	2.1548

Control Solution 8. The cocoa subsector (excluding X1), nonstatic solution, 1956-1969.

	$\hat{U}$	AE	RMSE
QSC1	.8181	0.0	27.4970
QDC	.4197	-.0513	11.3859
PCWPUS	.6608	.3781	34.1233
P1	.8776	1.0521	59.2859
P160X1	1.0499	-2.9373	60.5166
QSC	.4414	0.0	12.5858
SC	.3468	-.6663	20.4600

Control Solution 9. The macroeconomy, nonstatic solution, 1957-1969.

	$\hat{U}$	AE	RMSE
C	1.4642	.6350	97.8313
YD	1.2239	.9130	66.9164
E1	.9078	.0235	36.3495
UR	1.1145	.4807	83.4628
W1	.7863	.4980	23.6106
P2	.7141	.4655	27.7340
NNP	1.2156	.8194	65.4605
TY	.7099	1.6742	21.1073
GYD	.5927	1.7000	49.4963
U	1.0984	-.2687	79.1548
PNDPNDP	.0715	.0914	1.9364

APPENDIX IX

Dynamic multipliers for the simulation model

QSC1
Base value[1] = .23258

	PF	YOECD	QSC2
1956	0.0	-	-
1957	0.0	-	-
1958	0.0	-	-
1959	0.0	-	-
1960	0.0	-	-
1961	.0137	-	-
1962	.0137	-	-
1963	.0137	-	-
1964	.0353	-	-
1965	.0353	-	-
1966	.0353	-	-
1967	.0353	-	-
1968	.0353	-	-
1969	.0353	-	-

1. The 1957 Control solution forecasted value.

QDC
Base value = .85054

	PF	YOECD	QSC2
1956	0.0	0.0	.0082
1957	0.0	.0151	.0141
1958	0.0	.0113	.0185
1959	0.0	.0085	.0206
1960	0.0	.0070	.0215
1961	.0030	.0060	.0225
1962	.0052	.0052	.0234
1963	.0067	.0048	.0241
1964	.0119	.0047	.0242
1965	.0160	.0043	.0248
1966	.0192	.0039	.0256
1967	.0220	.0036	.0263
1968	.0245	.0032	.0272
1969	.0267	.0027	.0282

X1

Base value = .2162

	PF	YOECD	QSC2
1956	0.0	-	-
1957	0.0	-	-
1958	0.0	-	-
1959	0.0	-	-
1960	0.0	-	-
1961	.0127	-	-
1962	.0127	-	-
1963	.0127	-	-
1964	.0328	-	-
1965	.0328	-	-
1966	.0328	-	-
1967	.0328	-	-
1968	.0328	-	-
1969	.0328	-	-

QSC

Base value = .8521

	PF	YOECD	QSC2
1956	0.0	-	-
1957	0.0	-	-
1958	0.0	-	-
1959	0.0	-	-
1960	0.0	-	-
1961	.0137	-	-
1962	.0137	-	-
1963	.0137	-	-
1964	.0353	-	-
1965	.0353	-	-
1966	.0353	-	-
1967	.0353	-	-
1968	.0353	-	-
1969	.0353	-	-

SC

Base value = .2640

	PF	YOECD	QSC2
1956	0.0	0.0	.0228
1957	0.0	-.0151	.0398
1958	0.0	-.0264	.0522
1959	0.0	-.0349	.0626
1960	0.0	-.0419	.0720
1961	.0107	-.0479	.0805
1962	.0192	-.0531	.0880
1963	.0261	-.0579	.0949
1964	.0496	-.0627	.1017
1965	.0690	-.0670	.1079
1966	.0850	-.0709	.1132
1967	.0983	-.0743	.1179
1968	.1092	-.0776	.1217
1969	.1178	-.0803	.1245

	PF	YOECD	QSC2
PCW/PUS Base value = 33.9080			
1956	0.0	0.0	-1.5097
1957	0.0	1.3894	-2.5932
1958	0.0	2.0762	-3.4192
1959	0.0	2.5917	-3.7955
1960	0.0	2.8729	-.9704
1961	-.5588	3.0685	-4.1551
1962	-.9556	3.1992	-4.3276
1963	-1.2399	3.2793	-4.4462
1964	-2.1925	3.2960	-4.4600
1965	-2.9468	3.3693	-4.5829
1966	-3.5662	3.4509	-4.7321
1967	-4.0595	3.5209	-4.8545
1968	-4.5146	3.5780	-5.0217
1969	-4.9250	3.6662	-5.1975

	PF	YOECD	QSC2
P1 Base value = .46925			
1956	0.0	0.0	0.0
1957	0.0	0.0	-.0205
1958	0.0	.0190	-.0355
1959	0.0	.0298	-.0490
1960	0.0	.0372	-.0545
1961	0.0	.0416	-.0575
1962	-.0081	.0442	-.0605
1963	-.0140	.0470	-.0636
1964	-.0184	.0486	-.0659
1965	-.0328	.0494	-.0668
1966	-.0446	.0510	-.0694
1967	-.0554	.0536	-.0736
1968	-.0643	.0557	-.0768
1969	-.0741	.0587	-.0824

	PF	YOECD	QSC2
P160X1 Base value = 101.930			
1956	0.0	0.0	0.0
1957	-.0001	0.0	-5.275
1958	.0001	0.0	-5.155
1959	0.0	2.741	-12.213
1960	-.0001	13.326	-19.515
1961	6.3031	20.240	-28.042
1962	1.3503	24.348	-32.970
1963	-2.3770	25.507	-34.503
1964	4.5020	21.351	-28.949
1965	-7.3946	33.328	-45.097
1966	-14.8010	34.802	-47.337
1967	-12.1710	22.913	-31.419
1968	-9.0595	15.485	-21.350
1969	-7.9948	15.396	-21.609

	P160X1	YOECD	QSC2	PF
GDP Base value = 841.40				
1957	11.519	0.0	0.0	0.0
1958	12.528	0.0	-3.800	0.0
1959	12.394	6.615	-11.875	0.0
1960	13.263	22.779	-32.654	0.0
1961	13.975	43.586	-57.105	0.0
1962	14.784	58.824	-73.980	13.890
1963	15.824	67.288	-84.988	2.754
1964	16.196	68.455	-86.361	-5.093
1965	17.460	96.184	-121.050	12.197
1966	19.152	109.560	-138.340	-14.275
1967	19.538	72.773	- 92.562	-19.176
1968	19.145	45.695	-58.831	-13.045
1969	18.858	43.427	-56.819	-9.767

GDP
Base value = 841.40

	CSP	CSX	NTI
1957	.1533	.3975	-.0979
1958	.1564	.3288	-.0811
1959	.1482	.3355	-.0832
1960	.1500	.2990	-.0752
1961	.1520	.2717	-.0673
1962	.1544	.2837	-.0713
1963	.1574	.2609	-.0650
1964	.1530	.2361	-.0595
1965	.1566	.2335	-.0581
1966	.1567	.2660	-.0665
1967	.1606	.1973	-.0479
1968	.1593	.1581	-.0398
1969	.1553	.1624	-.0404

GDP
Base value = 841.40

	GC60	S2
1957	4.7108	-.0620
1958	4.7907	-.0519
1959	4.5237	-.0530
1960	4.6103	-.0478
1961	4.6452	-.0426
1962	4.7506	-.0455
1963	4.8246	-.0413
1964	4.7066	-.0379
1965	4.7776	-.0369
1966	4.8465	-.0427
1967	4.9081	-.0300
1968	4.9026	-.0252
1969	4.7732	-.0259

GYD
Base value = 85.075

	P160X1	YOECD	QSC2	PF
1957	.5912	0.0	0.0	0.0
1958	.6236	0.0	-4.101	0.0
1959	.6206	6.341	-11.236	0.0
1960	.6743	6.0	-8.542	0.0
1961	.7113	5.849	-7.635	0.0
1962	.6897	6.959	-8.803	1.873
1963	.7687	8.108	-10.196	.562
1964	.8373	8.660	-10.882	-.405
1965	.9675	10.387	-13.027	2.076
1966	.9535	10.525	-13.252	-.554
1967	.9832	12.453	-15.738	-3.952
1968	1.1612	21.387	-27.120	-15.747
1969	1.1300	21.063	-27.163	-14.587

GYD
Base value = 85.075

	CSP	CSX	NTI
1957	.0058	.0412	-.0102
1958	.0059	.0354	-.0088
1959	.0055	.0366	-.0090
1960	.0057	.0337	-.0084
1961	.0060	.0315	-.0078
1962	.0057	.0307	-.0077
1963	.0060	.0285	-.0072
1964	.0061	.0272	-.0069
1965	.0070	.0295	-.0073
1966	.0063	.0300	-.0075
1967	.0068	.0240	-.0058
1968	.0079	.0235	-.0060
1969	.0076	.0236	-.0059

	GC60	S2
GYD		
Base value = 85.075		
1957	.1777	.0718
1958	.1820	.0727
1959	.1643	.0726
1960	.1754	.0730
1961	.1813	.0734
1962	.1741	.0734
1963	.1847	.0737
1964	.1898	.0739
1965	.2098	.0737
1966	.1937	.0736
1967	.2026	.0747
1968	.2461	.0744
1969	.2342	.0745

	P160X1	YOECD	QSC2	PF
G				
Base value = 75.621				
1957	0.0	0.0	0.0	0.0
1958	0.0	0.0	-.3719	0.0
1959	0.0	.5735	-1.0148	0.0
1960	0.0	.4615	-.6550	0.0
1961	0.0	.3456	-.4488	0.0
1962	0.0	.4032	-.5071	.6784
1963	0.0	.4580	-.5725	.6295
1964	0.0	.4845	-.6050	.5973
1965	0.0	.4806	-.5975	1.7990
1966	0.0	.4831	-.6025	1.7888
1967	0.0	.8289	-1.0417	1.5891
1968	0.0	1.7502	-2.2098	.5612
1969	0.0	1.7390	-2.2342	.6783

	P16OX1	YOECD	QSC2	PF
S				
Base value = 29.468				
1957	.5912	0.0	0.0	0.0
1958	.6236	0.0	-4.101	0.0
1959	.6206	6.341	-11.236	0.0
1960	.6743	6.0	-8.542	0.0
1961	.7113	5.849	-7.635	0.0
1962	.6897	6.959	-8.803	1.261
1963	.7687	8.108	-10.196	-.077
1964	.8373	8.660	-10.882	-1.069
1965	.9675	10.387	-13.027	.262
1966	.9535	10.525	-13.252	-2.480
1967	.9833	12.453	-15.738	-5.979
1968	1.1612	21.387	-27.120	-17.879
1969	1.1299	21.063	-27.163	-16.750

	CSP	CSX	NTI
S			
Base value = 29.468			
1957	.0058	.0412	-.0102
1958	.0059	.0354	-.0088
1959	.0055	.0366	-.0090
1960	.0057	.0337	-.0084
1961	.0060	.0315	-.0078
1962	.0057	.0307	-.0077
1963	.0060	.0285	-.0072
1964	.0061	.0272	-.0070
1965	.0070	.0295	-.0073
1966	.0063	.0300	-.0075
1967	.0068	.0240	-.0058
1968	.0079	.0235	-.0060
1969	.0076	.0236	-.0059

	GC60	S2
S		
Base value = 29.468		
1957	.1777	.0718
1958	.1820	.0727
1959	.1643	.0726
1960	.1754	.0729
1961	.1813	.0734
1962	.1741	.0734
1963	.1847	.0737
1964	.1898	.0739
1965	.2098	.0737
1966	.1937	.0736
1967	.2026	.0747
1968	.2461	.0744
1969	.2342	.0745

	P160X1	YOECD	QSC2	PF
I1R1				
Base value = 87.153				
1957	2.2123	0.0	0.0	0.0
1958	2.9535	0.0	-1.480	0.0
1959	3.0282	2.689	-4.758	0.0
1960	3.4190	6.757	-9.591	0.0
1961	3.8959	12.799	-16.623	0.0
1962	4.3039	17.739	-22.316	4.1642
1963	4.8211	21.367	-26.707	.8159
1964	5.3497	23.540	-29.393	-1.8363
1965	6.0335	34.160	-42.465	4.1335
1966	6.8380	40.681	-50.763	-5.4095
1967	7.0678	27.748	-34.873	-7.5589
1968	7.1827	19.048	-24.051	-6.6614
1969	7.1253	18.776	-24.123	-5.6806

I2R2
Base value = 22.938

	P160X1	YOECD	QSC2	PF
1957	2.6917	0.0	0.0	0.0
1958	2.8309	0.0	-.790	0.0
1959	2.7847	1.371	-2.468	0.0
1960	2.9988	5.065	-7.268	0.0
1961	3.1326	9.707	-12.727	0.0
1962	3.2318	12.643	-16.077	3.0512
1963	3.4061	14.400	-18.207	.6179
1964	3.4244	14.375	-18.161	-1.0423
1965	3.6507	20.009	-25.217	2.6297
1966	3.9964	22.716	-28.730	-2.9025
1967	4.0374	14.879	-18.969	-3.8633
1968	3.9037	9.089	-11.757	-2.4318
1969	3.7997	8.453	-11.115	-1.7042

I2R2
Base value = 22.938

	CSP	CSX	NTI
1957	.0140	.0995	-.0245
1958	.0147	.0823	-.0203
1959	.0128	.0844	-.0209
1960	.0134	.0754	-.0190
1961	.0139	.0684	-.0171
1962	.0145	.0714	-.0180
1963	.0149	.0641	-.0160
1964	.0140	.0581	-.0147
1965	.0146	.0572	-.0152
1966	.0150	.0657	-.0165
1967	.0161	.0488	-.0119
1968	.0158	.0392	-.0099
1969	.0149	.0404	-.0100

I2R2
Base value = 22.938

	GC60	S2
1957	.4291	-.0154
1958	.4490	-.0130
1959	.3680	-.0132
1960	.4127	-.0120
1961	.4208	-.0108
1962	.4459	-.0113
1963	.4550	-.0102
1964	.4298	-.0093
1965	.4391	-.0090
1966	.4679	-.0900
1967	.4854	-.0074
1968	.4872	-.0063
1969	.4571	-.0064

M
Base value = .2184

	P160X1	YOECD	QSC2	PF
1957	.0034	0.0	0.0	0.0
1958	.0036	0.0	-.0006	0.0
1959	.0036	.0009	-.0018	0.0
1960	.0039	.0060	-.0087	0.0
1961	.0041	.0124	-.0163	0.0
1962	.0040	.0152	-.0194	.0039
1963	.0045	.0185	-.0235	.0009
1964	.0049	.0200	-.0254	-.0013
1965	.0056	.0303	-.0384	.0045
1966	.0055	.0309	-.0393	-.0037
1967	.0057	.0205	-.0263	-.0051
1968	.0068	.0148	-.0193	-.0033
1969	.0066	.0136	-.0181	-.0020

M

Base value = .2184

	CSP	CSX	NTI
1957	-	.0002	-
1958	-	.0002	-
1959	-	.0002	-
1960	-	.0002	-
1961	-	.0001	-
1962	-	.0001	-
1963	-	.0001	-
1964	-	.0001	-
1965	-	.0001	-
1966	-	.0001	-
1967	-	0.0	-
1968	-	0.0	-
1969	-	0.0	-

M

Base value = .2184

	GC60	S2
1957	.0010	-
1958	.0011	-
1959	.0010	-
1960	.0010	-
1961	.0011	-
1962	.0010	-
1963	.0011	-
1964	.0011	-
1965	.0012	-
1966	.0011	-
1967	.0012	-
1968	.0014	-
1969	.0014	-

PC
Base value = .0841

	P160X1	YOECD	QSC2	PF
1957	-.0008	0.0	0.0	0.0
1958	-.0018	0.0	.0004	0.0
1959	-.0011	-.0005	.0010	0.0
1960	-.0013	-.0019	.0029	0.0
1961	-.0015	-.0042	.0061	0.0
1962	-.0013	-.0049	.0071	-.0007
1963	-.0016	-.0067	.0098	.0003
1964	-.0019	-.0076	.0119	.0012
1965	-.0019	-.0104	.0161	.0002
1966	-.0021	-.0091	.0146	.0028
1967	-.0028	-.0094	.0147	.0047
1968	-.0031	-.0091	.0131	.0051
1969	-.0034	-.0079	.0115	.0041

PC
Base value = .0841

	GC60	S2
1957	-.0003	-
1958	-.0005	-
1959	-.0004	-
1960	-.0004	-
1961	-.0005	-
1962	-.0004	-
1963	-.0005	-
1964	-.0006	-
1965	-.0006	-
1966	-.0004	-
1967	-.0007	-
1968	-.0010	-
1969	-.0009	-

	P160X1	YOECD	QSC2	PF
UR Base value = 7.059				
1957	-.4122	0.0	0.0	0.0
1958	-.5609	0.0	.1335	0.0
1959	-.5894	-.2242	.4429	0.0
1960	-.6223	-.8223	1.2168	0.0
1961	-.6458	-1.6539	2.2116	0.0
1962	-.6758	-2.3674	3.0438	-.4454
1963	-.7077	-2.8376	3.6024	-.2454
1964	-.7244	-3.0066	3.8009	.0548
1965	-.7537	-3.7967	4.7841	-.3535
1966	-.8054	-4.4222	5.5803	.2366
1967	-.8302	-3.6268	4.5964	.5885
1968	-.8128	-2.5706	3.2816	.5436
1969	-.8123	-2.1519	2.7826	.4478

	CSP	CSX	NTI
UR Base value = 7.059			
1957	-.0054	-.0371	.0036
1958	-.0071	-.0404	.0039
1959	-.0072	-.0427	.0040
1960	-.0072	-.0394	.0037
1961	-.0072	-.0354	.0033
1962	-.0072	-.0347	.0033
1963	-.0072	-.0316	.0031
1964	-.0070	-.0287	.0029
1965	-.0070	-.0271	.0026
1966	-.0069	-.0284	.0028
1967	-.0069	-.0237	.0023
1968	-.0067	-.0192	.0020
1969	-.0067	-.0183	.0018

UR
Base value = 7.0587

	GC60	S2
1957	-.1686	.0023
1958	-.2176	.0026
1959	-.2195	.0026
1960	-.2208	.0024
1961	-.2190	.0021
1962	-.2210	.0021
1963	-.2209	.0020
1964	-.2157	.0018
1965	-.2124	.0017
1966	-.2119	.0018
1967	-.2122	.0014
1968	-.2080	.0012
1969	-.2065	.0012

W1
Base value = .5020

	P160X1	YOECD	QSC2	PF
1957	-.0014	0.0	0.0	0.0
1958	-.0019	0.0	.0009	0.0
1959	-.0013	-.0011	.0018	0.0
1960	-.0012	-.0030	.0045	0.0
1961	-.0006	-.0047	.0077	0.0
1962	.0001	-.0022	.0048	0.0
1963	-.0015	-.0073	.0129	.0034
1964	-.0021	-.0081	.0146	.0054
1965	-.0017	-.0140	.0268	.0042
1966	-.0023	-.0052	.0139	.0123
1967	-.0046	-.0086	.0171	.0174
1968	-.0053	-.0101	.0174	.0178
1969	-.0061	-.0093	.0158	.0134

W1	GC60	S2
Base value = .5020		
1957	-.0006	-
1958	-.0008	-
1959	-.0003	-
1960	-.0002	-
1961	-.0001	-
1962	0.0	-
1963	-.0004	-
1964	-.0006	-
1965	-.0006	-
1966	-.0001	-
1967	-.0013	-
1968	-.0023	-
1969	-.0016	-
		-

APPENDIX X

Problems arising from the data used in the econometric model

The variables listed in APPENDIX IV were drawn from a range of publications, but principally from three sources : a set of national accounts for Ghana compiled by Merritt-Brown (1972); cocoa statistics derived from Gill and Duffus (1971); and data published by the Ghanaian government. Since the series varied in quality, this APPENDIX is set aside for a brief discussion of the major problems associated with the data and an appraisal of its quality.

The quality of the data used in the final equations for the cocoa subsector was generally very good since most of the series were obtained from a reliable source - Gill and Duffus. The variables were simply converted, where necessary, to calendar year by averaging the crop year data. The selection of the New York spot price of Ghanaian cocoa beans as representative of the world price was justified in as much as all cocoa prices tend to move in harmony; Ghana produces about one third of total output; and the United States consumes about a quarter of total output. This latter fact also lies behind the choice of the United States wholesale price index as a deflator for the world price. We also felt confident in the estimation of an aggregate demand function for cocoa in so far as consumption is concentrated in developed countries; the oligopolistic nature of the chocolate market ensures stable market shares; and manufacturers' reactions to changes in price tend to be interdependent and parallel. We were, however, less confident with regard to the aggregation of the cocoa supply function, given the potential for regional variation in ecological and climatic conditions in Ghana; but regional disaggregation with respect to the 'experiments' described in chapter 2 did not improve upon the results obtained. The major weakness, therefore, in this sector stemmed from the lack of data on such things as farmer costs, yields, capital stock, taxes and rainfall; or from the poor quality of the series for substitute crops in production.

As far as aggregate demand is concerned, the aggregates do not appear unreasonable, although there was a discrepancy between the public finance accounts and the national accounts as compiled by Merritt-Brown (1972) regarding government consumption. We relied upon the latter's estimates. The capital stock data was satisfactory except for the fact that the figures for building and construction and transport, machinery and equipment included non-business government expenditure. Abbey and Scott Clark (1974) did attempt to separate out this element but we were unable to repete their computations. The major departure from the social accounts related to imports and exports. Non-cocoa exports were derived as the difference between the constant value of total exports of goods and non-factor services from Merritt-Brown and the real value of cocoa exports from the cocoa subsector. The various import categories were assembled from sources outside the national accounts (see APPENDIX V) but were reconciled with them by taking nonvisibles as the difference between total imports from the accounts and the sum of the individual SITC categories. Finally, due to the discrepancy between the aggregate of real visible and nonvisible imports by SITC breakdown and the figures from the accounts, the residual was added to inventories. In these cases where the series were obtained as residuals and represented 'catch-alls' i.e. non-cocoa exports, nonvisible imports and inventories, we treated them as exogenous in the model.

Most of the problems associated with the aggregate supply data had already been catered for by Merritt-Brown by adjusting the labour statistics to handle difficulties raised by the re-deployment period, discontinuities (with no apparent explanation) and seemingly unrealistic estimates of unemployment levels in later years. Figures for labour income, taxes and depreciation conformed well with expectations, but problems arose with the income of property and enterprise. No disaggregation was possible for this category and global estimates of profit income were derived as a residual by subtracting all other income components from gross domestic product. This resulted in negative global profits for 1961 and 1962. There is some casual evidence that state-run enterprises were operating under heavy inefficiencies but it is also possible that the data is inaccurate in this case. Also it was not possible to separate out the income of property and enterprise between private and government business.

With regard to the government sector, both the budget and balance of payments, the need to assemble the data into categories which have the most economic meaning involved making estimates, interpolations and approximations. The usual caveat about errors and weaknesses in the data is particularly relevant here. For example, it was not possible to exclude that part of government owned business where administrative departments sold goods and services to the general public and recorded the sales as general government revenue. Similarly, where there is an overlap between transactions with the rest of the world and the national accounts data, the data should be identical or the divergencies recorded and explained. This is generally not done and was not done by Merritt-Brown. This meant, for example, that the international monetary balancing figures from the balance of payments sheet do not conform to the data on changes in reserves compiled by the International Monetary Fund.

Finally, we turn to money and prices. The data was generally good, although not all of the series in the monetary sector went back to 1956. Trend estimates were therefore substituted by Merritt-Brown. The definitions of 'money' and 'high-powered money' are, of course, themselves arbitrary. The former was taken to include deposits with savings institutions which can be turned into currency at short notice and without capital loss. The latter included currency (coin plus paper money) issued by the Central Bank together with commercial bank deposits with the Central Bank. The cash reserves of the commercial banks consist of currency and deposits with the Central Bank. Implicit price indexes were derived by Merritt-Brown for the major sectors of gross domestic expenditure by dividing the series for each major sector in current new cedis by the corresponding values in constant new cedis. These indexes were then moved back from 1959 to 1956. Import price indices were taken from government sources and Leith (1974), and were left as exogenous. In the absence of data on the price of inventories, nominal inventory spending was derived residually from the nominal gross domestic product identity.

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